# POWER

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## Amiability

I HAD an experience recently with a man who reminded me of a green apple. He was small and crabbed and sour.

I was not trying to sell him anything or to get him to give anything away or to do anybody a favor; but he maintained throughout the brief interview an aspect of crabbed repulsion and crustiness.

Fortunately, he is young. He will ripen and mellow with age if he does not get bitten into too deeply in the meantime.

He will learn, as he gets away from the little twig of small-town business of which he is the heritor and the fruit, the value of friendship and sociability, the winning power of a smile, the sweetening influence of human kindliness.

But he had better hang to his twig until he grows some bigger, softens up a bit, loses some of his greenness and takes on a more inviting aspect. If he ever got out into the world as he is now, he would stand about as much chance for reception and acceptance as a half-grown cider apple in a basket of fancy fruit.

F. R. Low

# Conserving Waste Heat in the Making of Corn Syrup

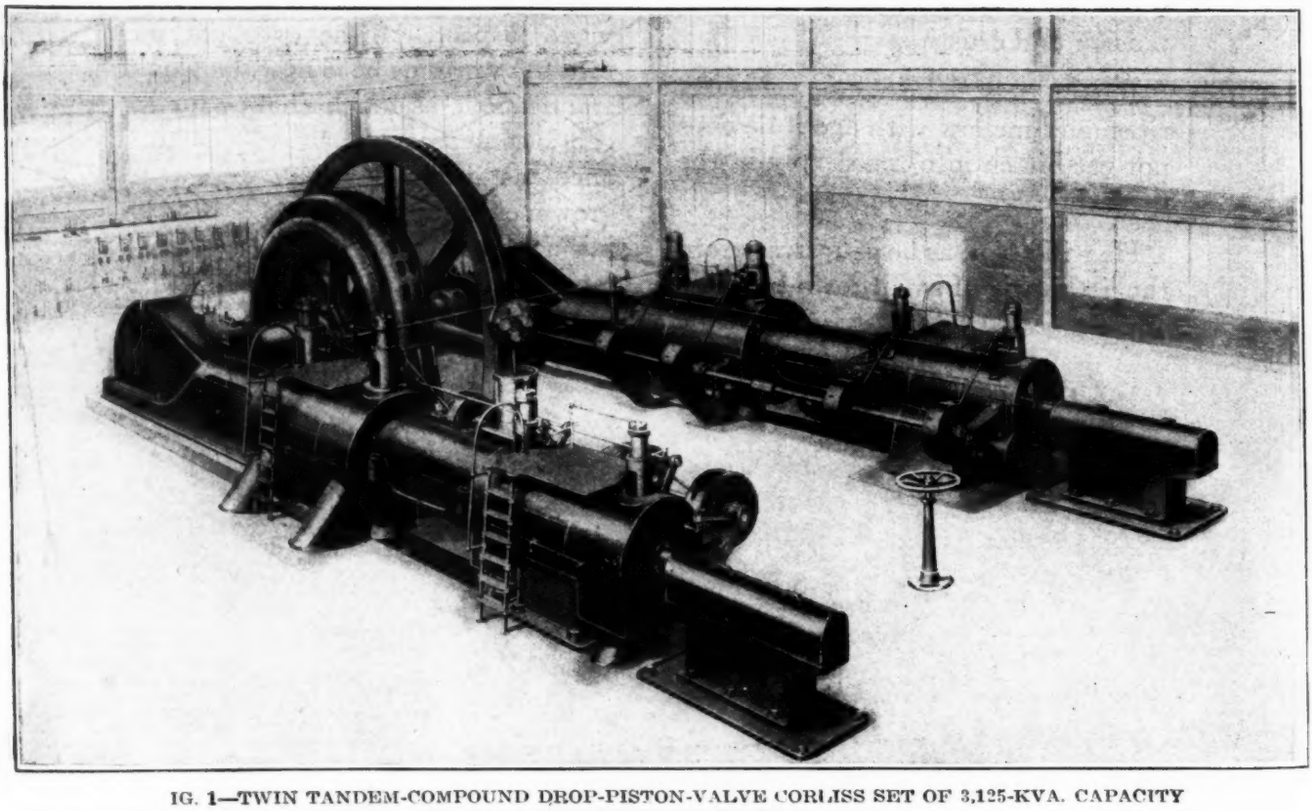
By THOMAS WILSON

**ALL exhaust steam from power generation used in the processes, while the gases of combustion are used for drying. Modern boiler plant using forced-draft chain-grate stokers. Plant contains 2,500 kw. direct connected steam-engine unit**

IN ITS new plant at Kansas City, which has capacity to convert 20,000 bushels of corn per day into corn syrup, and the usual by-products, edible oils and "feed," the Corn Products Refining Co. has introduced a number of features adding greatly to the economy of the process. Power demands for driving the mills, conveyors and the varied machinery in the plant and for pumping large quantities of water, are heavy, and large volumes of steam are required in the processes and for drying and heating. Except for converting starch to corn syrup and refining corn oil for Mazola, exhaust steam meets all temperature requirements and the quantity needed balances that available from power generation. The electrical load and the steam demands are nearly constant, so that a balance is maintained and a most economical condition established.

Having fully utilized the byproduct of power generation, the engineering department of the company did not rest here. There were other waste products to consider, and the one offering the greatest possibilities was the hot gases of combustion from the boilers. Great quantities of feed, principally the external covering or hull of the corn, had to be dried. Formerly, direct-heat driers were employed, taking the gases from separately fired dutch-oven furnaces, or perhaps the driers would be equipped with steam coils. In the present plant arrangements were made to pass the waste gases of combustion from the boilers through these driers. To meet the requirements, it was considered necessary to deliver the gases into the driers at a temperature of 630 deg. and allow them to escape to atmosphere at 130 deg. F., at which temperature the gases are saturated with moisture. In other words, most efficient economizers were at hand and their use probably added a net 10 per cent to the usual over-all economy to be expected from the boilers as well as eliminating the necessity of separate fires to do the drying.

In order that the highest ultimate economy might be secured, it was considered essential that the primary end of the power plant should be made up of modern and highly efficient equipment. Horizontal water-tube boilers, set high to give large furnace volumes, were installed. Forced-draft chain grates were selected to burn efficiently and at high capacity the inferior grades of fuel available and to establish practically a balanced draft over the fire. In this way the induced draft necessary to carry the gases over to the driers could be limited to that needed to remove the gases from the boilers, thus preventing undue leakage of cold air.



IG. 1—TWIN TANDEM-COMPOUND DROP-PISTON-VALVE CORLISS SET OF 3,125-KVA. CAPACITY

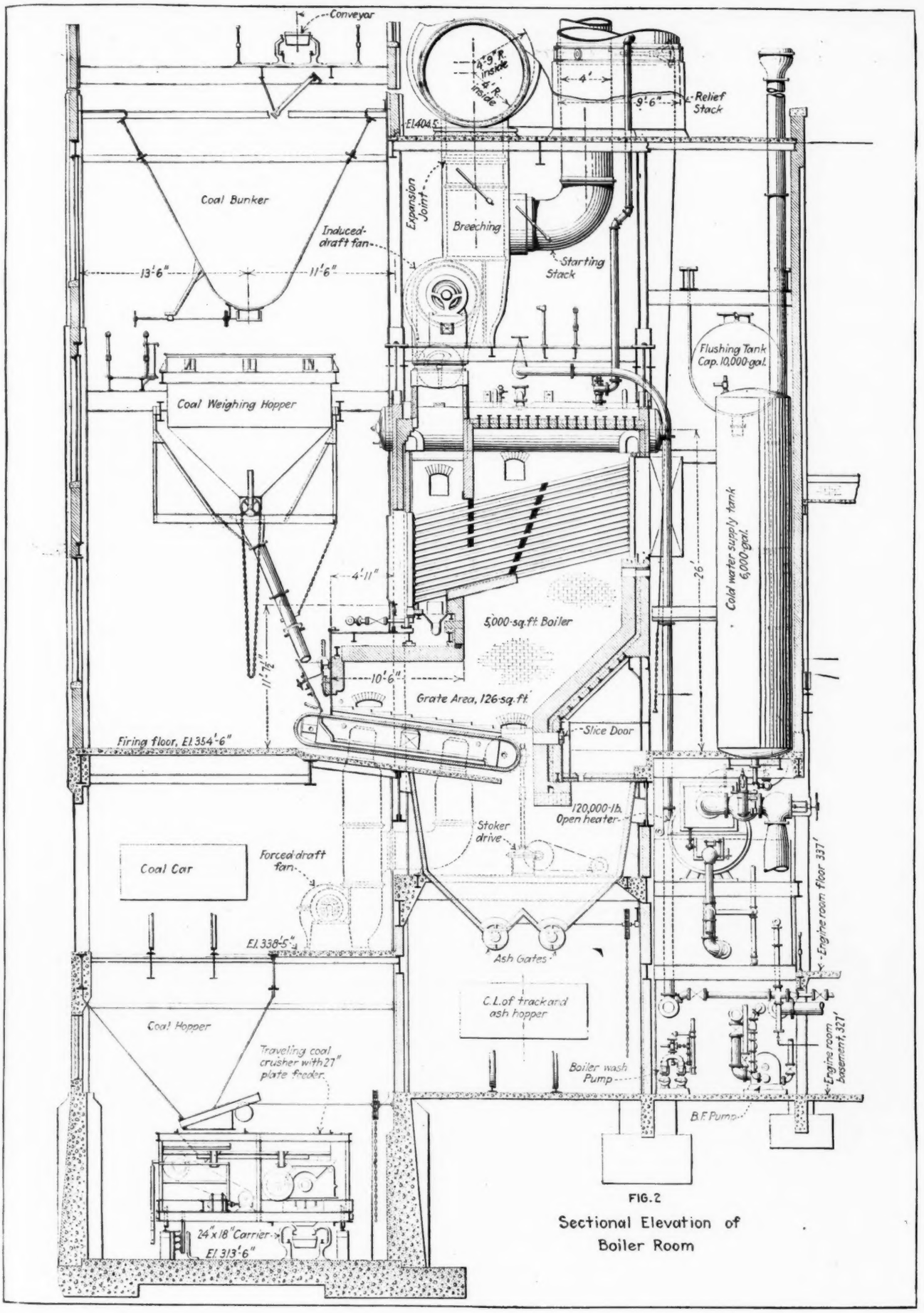



FIG. 2

Sectional Elevation of Boiler Room

As operation in the generation of power was to be non-condensing, with a definite back pressure, an engine was selected as the most economical type of prime mover. This engine was compounded to improve the economy, and the load being practically constant, only one generating unit was installed. With no reserve generating capacity, a heavy, substantial, slow-speed machine that would stand up in service was desired, so the selection turned to a twin tandem-compound drop-piston-valve Corliss engine. From such a machine continuous operation with a minimum of trouble, and therefore low upkeep, is anticipated. In the event that one side of the twin unit should be incapacitated for any reason, the other side can be continued in operation, so that a complete shutdown would not be probable. To eliminate possible inconvenience, the plant has a breakdown service connection for lighting. The machine is an engine-driven unit of 3,125 kva., or 2,500 kw. at 80 per cent power factor. Three-phase 60-cycle current at 440 volts is generated. The engine cylinders are 27 and 50 by 54 in., and the speed is 100 r.p.m.

In daily operation it is anticipated that the back pressure will not exceed 3 lb. gage. Under this condition and with a steam pressure at the boiler of 225 lb. gage and 200 lb. at the throttle, a steam consumption of 26 lb. per kilowatt-hour at full load is guaranteed. This gives a possible Rankine cycle efficiency of the unit of 74 per cent. There is little variation in steam consumption between $\frac{3}{4}$ and $1\frac{1}{4}$ load, the steam curve being practically flat between these limits. To take advantage of this rate, the various pumps with the exception of the boiler-feed pumps, as well as the other equipment in the works, are motor-driven. It is thus evident that economy was the watchword in the design, and the results obtained since the plant was put into operation show that all expectations have been realized.

Reference to Figs. 2 and 3 will show the general layout of the boiler room. Four two-drum water-tube boilers, each containing 5,000 sq.ft. of steam-making surface, have been installed to deliver saturated steam at 225-lb. gage pressure. With an extension of 4 ft. 11 in., forced-draft chain-grate stokers divided into four zones are set under the low ends of the boilers. An active grate area of 126 sq.ft. has a ratio to the steam-making surface of 1 to 40, thus giving unusually

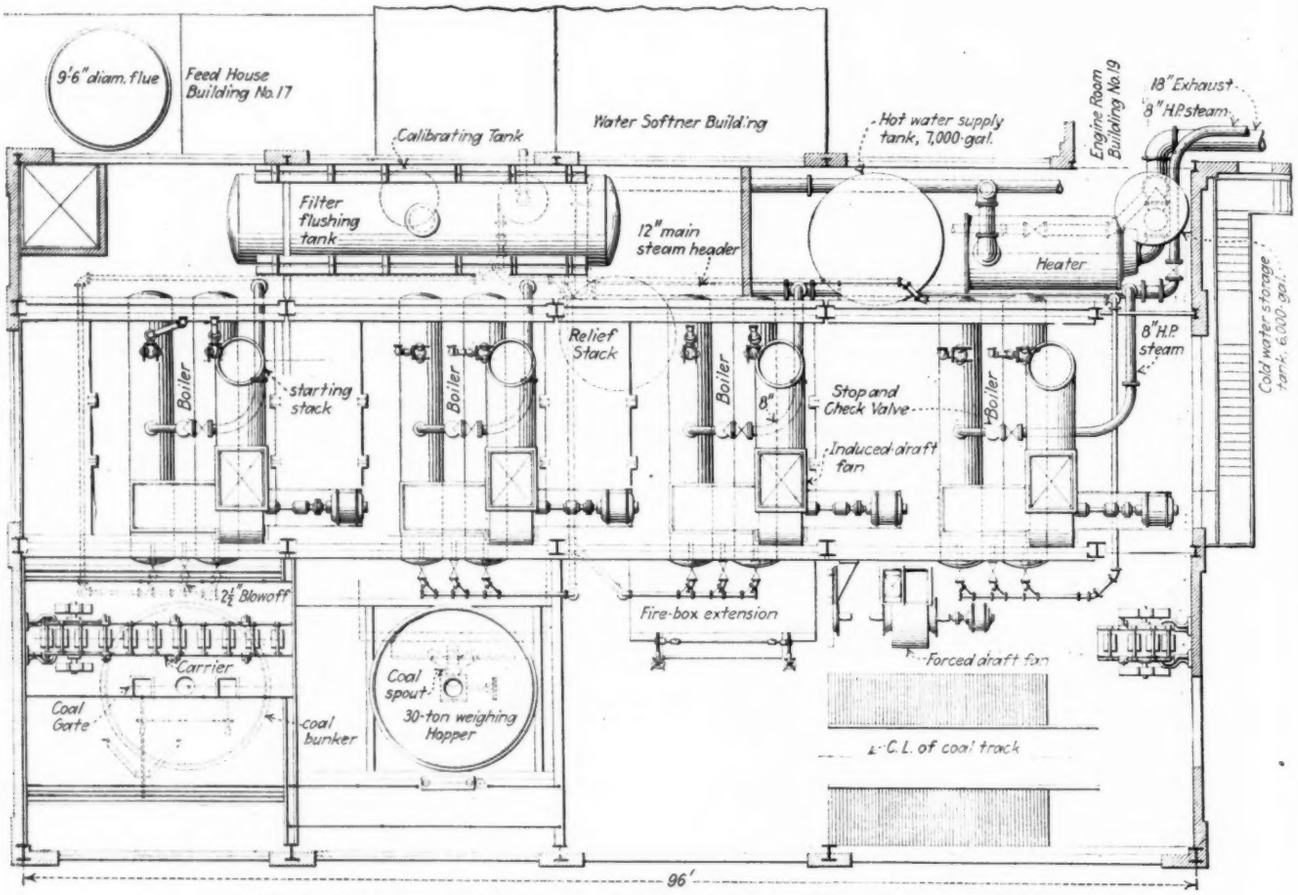



FIG. 3—PLAN OF BOILER ROOM, SHOWING ARRANGEMENT OF EQUIPMENT

large stokers with which there should be no difficulty in maintaining operation at the proposed average of 250 to 300 per cent of rating. Direct-current motors with a speed variation from 500 to 2,000 r.p.m. drive the stokers. They are located under the firing floor, away from the dust and heat, and are belted to the gearing forming the rear drive of the stoker. Individual forced-draft motor-driven fans supply the air for combustion. Their location is indicated in Fig. 2.

From the floor to the bottom of the front tube header the headroom is 11 ft. $7\frac{1}{2}$ in. This, in combination with a stoker sloping downward and the boiler tubes upward, gives a large combustion chamber and a flame travel exceeding 15 ft. from the rear of the stoker to the nearest heating surface. It is important that combustion be complete, as any smoke reaching the driers will color the feed and lessen its market value. The rear wall of the furnace has been carried in to form the bridge wall, with slicing and inspection

doors at the grate level. At the front is a 12-in. ignition arch and a flat suspended fire arch extending 10 ft. 6 in. into the furnace from the gate. From the end of the arch a tile wall is carried up to the tubes and the furnace roof continues in the form of C-tile over the lower row of tubes. The gas opening into the first pass at the rear is 9 ft. 6 in. long, this being reduced to 6 ft. 5 in. at the top by means of a sloping baffle continuing from the tile roof of the furnace. As this construction forms a soot pocket at the front of the boiler, a hand-operated soot conveyor has been placed between the arch and the lower row of tubes, as shown in Fig. 2.

By an induced-draft fan mounted over the uptake at the front of the boiler, the gases are drawn out of the setting, the suction or draft pressure being regulated by a damper whose position is controlled by means of a chain from the boiler-room floor. This fan has capacity to deliver 57,300 cu.ft. of 600-deg. gas per minute. It is driven directly at 514 r.p.m. by a 50-hp. three-phase alternating-current motor. The gases are discharged into a main flue leading to the feed house, and from this flue ducts lead to five direct-heat driers. To eliminate leakage, the induced-draft fans are operated so as to deliver the gas to the driers at practically atmospheric pressure. It is the duty of a second induced-draft fan at the discharge end of the drier to draw the gases through the feed and discharge them into a large cyclone. The small particles of feed carried along with the gases are returned to a screw conveyor feeding the drier, and the gases escape to the atmosphere.

For economical drying the entrance and exit temperatures for the gases have been placed at 630 and 130 deg. F., respectively. This means a temperature at the boiler uptake of approximately 685 deg. Recording thermometers are placed at the three points mentioned, and care is taken that approximately the desired temperatures are maintained.

### Auxiliary Stack Employed for Starting

As it is of great importance to keep smoke away from the driers, a starting stack of 4 ft. internal diameter has been provided for each boiler. It has connection between the induced-draft fan and the main gas flue. Both the uptake to the flue and the starting stack are dampered, with chain connections for manipulation from the boiler-room floor, so that either outlet for the gases may be utilized as desired. It is customary to use the starting stack until a good hot fire is built up on the grate, when the dampers are readjusted and the gases pass over to the feed house.

In addition some provision was necessary to guard against a sudden shutting down of the driers cutting off the discharge of the gases to the atmosphere. The solution to this problem was a relief stack connected to the main flue through a counterweighted damper mounted on ball bearings whose position is controlled by a special regulator operating on a water pressure of 0.6 in. at the fan. When the gas pressure reaches this point, the regulator will begin to open the damper and allow a portion of the gases to escape to the relief stack. As soon as the pressure drops back to normal, the counterweight closes the damper and operation is resumed as before.

Coal and ash handling has been made as simple and convenient as possible. The power-plant levels have been so arranged that railway cars are run directly under the stoker hoppers to receive the ash directly, without any intervening conveying machinery. As will be evident from Fig. 2, the ash hoppers are of unusual size, the cubic contents being approximately 1,500 cu.ft., which is sufficient to store the ash for a 36-hour run at the high ratings previously given. Two ash gates operated by chains through worm gearing have been provided, and the bottom has been designed to prevent arching over of the ash. Large airtight doors under the overhang at the rear give admission to the hopper.

Coal is brought into the building under the firing floor in the boiler room and dumped from railway cars directly into one of the two track hoppers provided to receive it. From the track hopper a 27-in. plate feeder introduces the coal into a 30x30-in. traveling coal crusher which discharges into a continuous bucket carrier elevating the coal to an overhead parabolic steel bunker of 400 tons capacity. Below the bunker is a 30-ton hopper with a beam scale for each boiler. Delivery to each stoker is effected through a chain-operated gate into a spout tricated at the delivery end to insure a uniform mixture of coal to the grate.

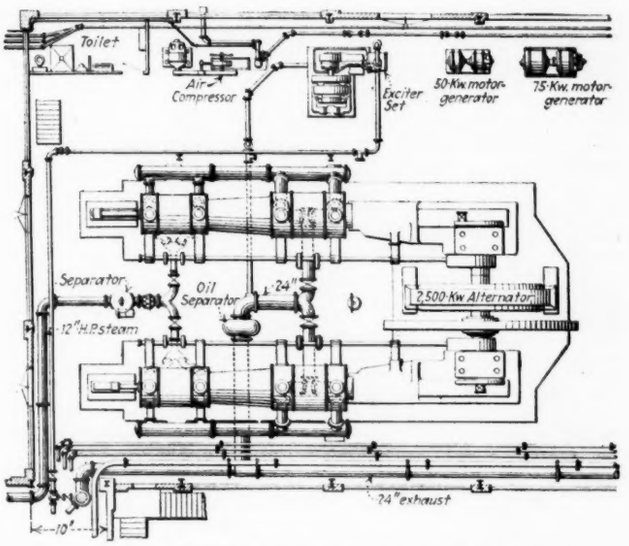



FIG. 4—GENERAL PLAN OF ENGINE ROOM

In the feed-water system also there are features of interest. The general supply, obtained from deep wells on the premises, is particularly hard, containing up to 45 grains of encrusting solids per U. S. gallon. For the processes this water is softened by lime-and-soda treatment and the scale-forming matter reduced to four or five grains per gallon. As the boilers operate at high rating and it is particularly important to keep them clean, the makeup water for boiler feed is taken from the general supply and passed through a Zeolite softener to be reduced to zero hardness.

Where possible the returns are brought back to a 7,000-gal. hot-water supply tank in which the level is maintained at 3,000 gal. by admission of makeup under float control from the Zeolite system. The boiler-feed pumps draw from this tank. As a typical example of the conservation of heat the condensate from the exhaust steam used in the evaporators in the refinery is returned to the boiler house. The vapor from the evaporators imparts its heat to the cooling water in the condenser. Part of this water is returned to the boiler house and the rest is used in process work.

For short intervals, say twenty minutes out of the

hour, a little exhaust steam is available to heat the feed water. An ingenious arrangement has been made to conserve the heat in this steam when there is a surplus and not draw from the supply when all of it is needed in the process work. Referring to Fig. 3, an open feed-water heater has been placed between the 7,000-gal. hot-water tank and a 6,000-gal. cold-water tank above the heater, which receives its supply from the Zeolite system. When the pressure in the main exhaust system exceeds 2 lb., an exhaust relief valve in the steam connection to the heater automatically opens and admits exhaust steam. A thermostat in the upper part of the heater then opens a valve in the line between the cold-water tank and the heater, admitting cold makeup water to absorb the surplus heat. Overflow from the heater is to the hot-water tank in which there is considerable reserve capacity to receive these sudden flushes of water. So long as a surplus of

## DATA ON MECHANICAL EQUIPMENT OF CORN PRODUCTS REFINING CO'S PLANT AT KANSAS CITY

### GENERAL

| | |
|---|---|
| Plant location | North Kansas City, Mo. |
| Character of service | Steam generation for both power and process work. |
| Type of building | Brick walls, steel structure |
| Boiler-room dimensions, inside | 56 ft. 6 in. x 96 ft. |
| Width of firing floor, ft | 18 |
| Width of passage behind boilers, ft | 10 |
| Height, fan floor to firing floor, ft | 16 |
| Engine-room dimensions | 61 ft. 6 in. x 100 ft. |

### BOILERS

| | |
|---|---|
| Manufacturer | Babcock & Wilcox Co. |
| Type | Horizontal, two-drum, water-tube |
| Number | 4 |
| Steam-making surface, sq.ft. | 5,000 |
| Grate area, active, sq.ft. | 126 |
| Steam-making surface per sq.ft. of grate, sq.ft. | 40 |
| Working pressure, lb. per sq.in., gage | 225 |
| Superheat | None |
| Coal burned | Illinois screenings |
| Height to center steam drum above firing floor, ft. | 26 |
| Height of bottom front tube header above firing floor ft.-in. | 11 ft., 7½ in. |
| Combustion furnace volume, cu.ft. | 1,600 |
| Furnace volume per sq.ft. of grate, cu.ft. | 12.7 |

### STOKERS

| | |
|---|---|
| Manufacturer | Combustion Engr. Corp. |
| Type | Coxe-forced-draft, chain-grate |
| Number of zones | 4 |
| Active grate area, sq.ft. | 126 |
| Stoker drive | D. C. variable speed motor |
| Motor hp. | 3 |
| Speed range, r.p.m. | 500–2,000 |
| Ignition arch, 12 in. | Liptak Fire-Brick Arch Co. |
| Fire arch, 10 ft. 10 in. wide, 10 ft. 6 in. long, from furnace front | Liptak Fire-Brick Arch Co. |

### FORCED-DRAFT FANS

| | |
|---|---|
| Manufacturer | B. F. Sturtevant Co. |
| Number installed | 4 |
| Type | Double inlet, turbo-vane |
| Capacity at 4 in. water pressure, cu.ft. per min. | 22,500 |
| Drive | Allis-Chalmers 440-volt, three-phase motor |
| Size, hp. | 25 |
| Speed, r.p.m. | 1,200 |
| Capacity of fan per sq.ft. of grate, cu.ft. per min. | 179 |
| Capacity of fan per cu.ft. of furnace volume, cu.ft. per min. | 14 |

### INDUCED-DRAFT FANS

| | |
|---|---|
| Manufacturer | B. F. Sturtevant Co. |
| Number installed | 4 |
| Type | Single inlet, multi-vane |
| Capacity, 3-in. water pressure, 600 deg. gases, cu.ft. per min. | 57,300 |
| Drive | Allis-Chalmers, 440-volt, three-phase motor |
| Motor hp. | 50 |
| Speed, r.p.m. | 514 |
| Fan capacity per sq.ft. of grate, cu.ft. per min. | 455 |
| Exhaust fans on driers | Garden City Fan Co. |
| Number installed | 5 |
| Type | 62 in. dia. blast wheel |
| Capacity, cu.ft. per min. against 2 in. water pressure | 20,000 |
| Speed, r.p.m. | 320 |
| Drive (belted) | Allis-Chalmers a.c. motor |
| Size, hp. | 15 |
| Speed, r.p.m. | 680 |

### COAL BUNKER

| | |
|---|---|
| Contractor | Bedford Construction Co. |
| Type | Parabolic, suspended, steel |
| Capacity, tons | 400 |
| Number of days storage at normal operation | 2 |
| Weighing hopper, 30 ton, and scale | Howe |
| Number installed | 4 |

### COAL-HANDLING EQUIPMENT

| | |
|---|---|
| Plate feeder, 27-in. | Jeffrey Mfg. Co. |
| Traveling coal crusher, 30x30-in., 50 tons per hr. | Jeffrey Mfg. Co. |
| Drive | Allis-Chalmers, 440-volt, Three-phase motor |
| Size, hp. | 40 |
| Speed, r.p.m. | 865 |

### COAL-HANDLING EQUIPMENT—Continued

| | |
|---|---|
| Peck carrier, 24x18 in. | Link Belt Co. |
| Drive | Allis-Chalmers, 440-volt, Three-phase motor |
| Size, hp. | 15 |
| Speed | 680 |
| Reducing gear 4½ to 1—worm reducing gear | Cleveland Worm Gear |

### FEED-WATER EQUIPMENT

| | |
|---|---|
| Two boiler-feed pumps, 3-in. 4-stage centrifugal | Allis-Chalmers Mfg. Co. |
| Capacity, gal. per min. | 375 |
| Head, lb. gage | 275 |
| Speed, r.p.m. | 3,000 |
| Drive | 125 hp. Kerr turbine |
| Boiler wash pump, 8x5x12 in. | Dean Bros. Steam Pump Works |
| Feed-water heater, 120,000 lb. per hour | H.S.B.W.-Cochrane Corp. |
| Pump governors 2½ in. angle | Fisher Governor Co. |
| Feed-water regulation | Hand regulated |
| Water-Softening System, Zeolite | Permutit Co. |
| Capacity, 5 grains per U. S. gal. to zero hardness, gal. per hour | 10,000 |

### STACKS

| | |
|---|---|
| Contractor | Conroy Boiler Works |
| Starting stacks, steel, number | 4 |
| Diameter, inside, ft. | 4 |
| Height above boiler-room roof, ft. | 30 |
| Relief stack, steel, number | 1 |
| Diameter, inside, ft.-in. | 9-6 |
| Height above boiler-room roof, ft | 30 |
| Damper regulator between breeching and relief stack | Engineer Co. |

### ENGINE ROOM

| | |
|---|---|
| One generating unit, 2,500-kw. | Allis-Chalmers Mfg. Co. |
| Engine, twin tandem-compound | 27x50x54 in. |
| Speed, r.p.m. | 100 |
| Generator | 440 volt, three-phase, 60-cycle |
| Capacity, kva. | 3,125 |
| Steam rate at full load (initial pressure 200 lb. gage; back pressure 5-lb. gage), lb. per kw.-hr. | 26 |
| Steam separator, 12-in. | Swartwout |
| Oil separator, 24-in. horizontal | Austin |
| Air compressor, feather valve, 300 r.p.m., 12x9-in. (Laidlaw) | Worthington Pump & Machinery Corp. |
| Capacity, cu.ft. free air per min. | 335 |
| Drive (belted) | Allis-Chalmers 30-hp motor |
| Exciter set, 80 kw. | Allis-Chalmers Mfg. Co. |
| Generator | Direct current, 125-volt, 275 r.p.m. |
| Engine, horizontal high-speed, 11 x 13-in. | A. L. Ide & Sons |
| Motor-generator, 75 kw., 1,200 r.p.m. | Allis-Chalmers Mfg. Co. |
| Generator | Direct-current, 125-volt, 1,200 r.p.m. |
| Motor | 440-volt, three-phase, 60-cycle |
| Motor-Generator, 45 kw. | Allis-Chalmers Mfg. Co. |
| Generator | Direct-current, 125-volt, 1,150 r.p.m. |
| Motor | 440-volt, three-phase, 60-cycle |
| Traveling crane, 20 ton, 60 ft. span | Whiting Corp. |
| Switchboard, designed and built by | H. Newgard Co. |

### MISCELLANEOUS EQUIPMENT

| | |
|---|---|
| Stop and check valves, 8-in. | Golden-Anderson Valve Specialty Co. |
| Blowoff valves, 2½-in. | Everlasting Valve Co. |
| Back-pressure relief valves, design | Corn Products Refining Co. |
| Safety valves, duplex | Ashton Valve Co. |
| Steam and water valves | Crane Co. |
| Steam piping, high-and low-pressure | Crane Co. |
| Firebrick | Walsh Fire Clay Products Co. |
| Insulation boiler setting | Sil-o-cel-Celite Products Co. |
| Low-water alarms | Davis |
| Exhaust heads | Swartwout |
| Pipe covering, 80 per cent magnesia | F. Sprinkman |
| Steam traps | Corn Products Refining Co. |
| Recording thermometers | Bristol Co. |
| $CO_2$ recorders | Uehling Instrument Co. |
| Steam-flow meters | Republic Flow Meters Co. |
| Water meters | Republic Flow Meters Co. |
| Pressure gages | Federal-Marshalltown Mfg. Co. |
| Draft gages, indicating | Precision Instrument Co. |
| Draft gages, recording | Uehling Instrument Co. |

exhaust steam exists, the heater continues to function, but just as soon as the pressure tends to fall below the 2-lb. limit, the exhaust steam and water admission valves automatically close and the heater is out of commission until an excess of exhaust steam is again available. Normally, little surplus is anticipated, but the heater in any event is considered a good investment, as it is always available to conserve heat that would otherwise be wasted.

Turbine-driven pumps feed the water to the boilers, and the flow is regulated by pump governors and hand control at the boilers. The pumps are of the four-stage type having capacity to deliver 375 gal. per min. at a discharge pressure of 275 lb. They are driven by 125-hp. steam turbines. Either one of the two units installed has sufficient capacity to meet requirements.

Economy and reliability were the chief factors entering into the selection of a prime mover for electrical generation. The conditions imposed were non-condensing operation and a back pressure up to 5 lb. gage. The analysis made resulted in the selection of a tandem-compound Corliss engine modified in design from the standard Corliss to permit of higher rotating speed. As previously stated, the engine is a twin machine with tandem-compound cylinders on either side driving a generator rated at 2,500 kw. at 80 per cent power factor.

### Drop Piston Valves Employed

From the usual Corliss-engine construction the engine differs in that the steam and exhaust valves are of the drop-piston type and all the valves are driven from a layshaft extending from the mainshaft to the end of the high-pressure cylinder. The steam and exhaust valves are operated directly by separate eccentrics on the layshaft, this construction eliminating the usual reciprocating parts between the mainshaft and the cylinders. To insure the sharp cutoff and the resulting economy of the standard Corliss, the steam valves are fitted with the usual releasing gears. To reduce the clearance space to a minimum, the valves are placed in the heads and, as they are almost perfectly balanced, permit the use of light valve gear.

Either element of the twin unit may be operated alone, as the tandem cylinders and their respective valve gear are independent of the opposing side and there are separate receivers between cylinders. Practically the same economy is obtainable whether one or the two elements are in operation, as either side is a complete compound unit in itself.

Fig. 4, a plan view of the engine room, shows the arrangement of the unit and the piping connections. An idea of the size will be gained from the extreme foundation measurements, which approximate 32 ft. wide by 65 ft. long. The floor space occupied is 2,080 sq.ft., which reduces to 0.83 sq.ft. per kilowatt of generator rating.

For the design of the plant and the general assembly credit is due the engineering department of the Corn Products Refining Co., of which Joseph J. Merrill is chief mechanical engineer and E. R. Skinner is first assistant.

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Copper piping can be bent by first annealing it thoroughly, then filling it with liquid heated rosin. Upon again heating it, it can be bent into curves and bends. After bending, however, it is again very brittle, and if further bending is desired it becomes necessary to again anneal it.

## Why Elevator Brakes Should Be Kept Clean

By William Zepernick

The elevator brake is possibly the most important adjunct of the equipment, as so much dependence is placed on it while the machine is in service, its principal function being to hold the elevator at rest. A brake that will hold an elevator machine at rest with full load in the car, will bring the machine to rest from full speed, as the friction exerted by the brake linings upon the brake wheel has a greater value when in motion than when at rest.

Between any two surfaces there is a drag developed when an attempt is made to move one surface over the other. After movement has started between the two surfaces, the drag is increased, which is due to a distinct difference between static friction and kinetic or friction due to motion. That this condition exists can easily be shown with a gearless type elevator that is equipped with leather brake linings. By adjusting the spring tension of the brake shoes so that it will permit the elevator to creep with full load, it will be found that the machine will creep at a fairly constant rate and not increase its speed. As gravity is the determining factor here that causes motion, it should cause the load to accelerate in its downward travel as it would do if the brake were not applied. The brake, then, must oppose the acceleration, which it can do only by providing a drag on the brake wheel equal to the unbalanced load. The forces exerted on any object at rest or in motion at a given velocity are in equilibrium (balanced), therefore with full load on the car and the brake-spring tension slacked off to permit the elevator to creep, the speed increases until the kinetic friction of the brake shoes has reached a value that will retard any further increase in speed.

These conditions, existing as they do, should clearly show the advisability of keeping all foreign substances clear of the brake-shoe linings, as these alter the character of the linings and therefore obtain a different friction characteristic. There are extreme cases where it is found necessary to use a dressing of some kind on the brake linings, but the greatest discretion should be exercised when doing so and it should be done only when necessity demands.

When brake linings are cared for properly by guarding against dirt and oil accumulating upon the surfaces of the brake wheel and linings, no trouble should be experienced; however, when this has happened, it is sometimes necessary to apply some foreign substance to the brake wheel to clean it, or to provide a softer or quicker stop for the elevator. This practice is not to be sanctioned, as the proper method is to remove the brake shoes and clean thoroughly.

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Mortar for laying up firebrick is too often made of fireclay alone. This is very bad practice for the reason that a mortar made of fireclay alone has no permanent body, and after it has been subjected to heat for some time it crumbles from between the bricks. A satisfactory mortar for this purpose may be made by mixing ½ ton of fireclay and 1 ton of firebrick dust (crushed firebrick) to the proper consistency, for each 1,000 firebrick laid. The brick dust, or crushed firebrick, should be the size of a pea and smaller. This mortar, when set, forms a compact refractory binding that is as strong as the brick itself.

# Tests of Stirling Boiler at Connors Creek Station

By PAUL W. THOMPSON*
Technical Director, Operation of Generating Plants, Detroit Edison Company

**EXTENDED series of tests to determine best baffling arrangement for boiler, suitability of four different kinds of coal, the heat losses, energy used by auxiliaries, time interval between flue blowing, coal for banking and other data tending to improve economy.**

SINCE the original installation of the large Type W Stirling boilers by the Detroit Edison Company in 1911, many improvements have been made and much experience has been gained in regard to bettering the overall performance of these steam-generating units. The results of the first tests conducted on this type of boiler were presented before the Society by Dr. D. S. Jacobus in 1911. Several years of experience in operating these boilers had brought about many improvements, yet it was felt that there still remained further opportunities for improving the operating performance. The determination of means for obtaining improved performance comprised the main purpose of these tests.

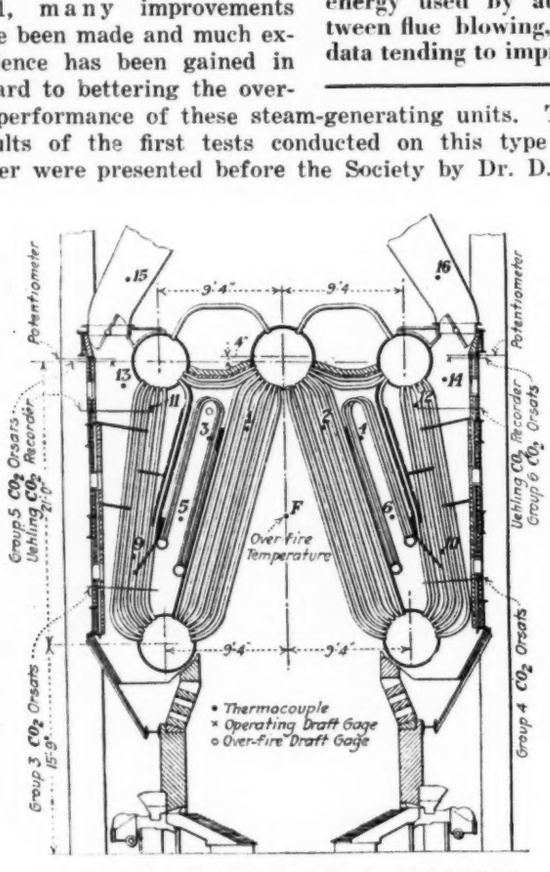


FIG. 1—ORIGINAL BAFFLE ARRANGEMENT

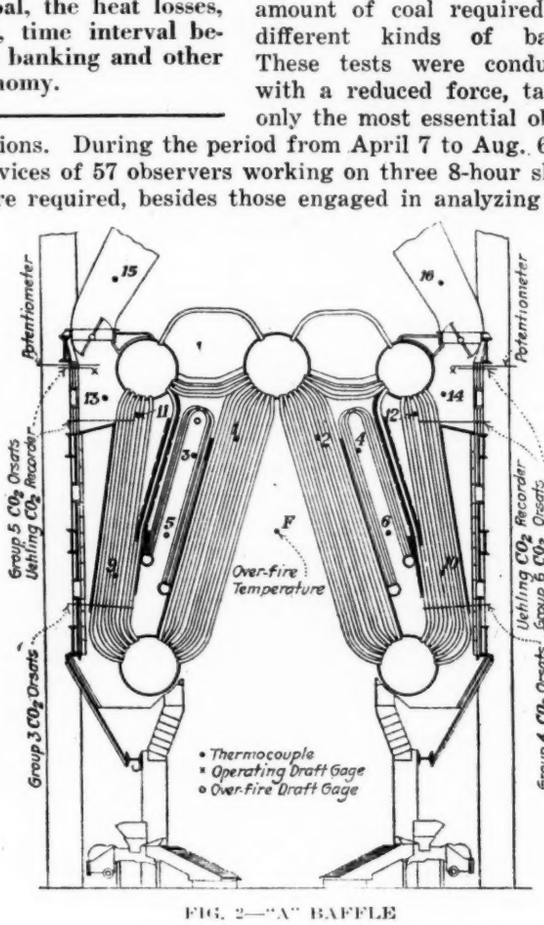


FIG. 2—"A" BAFFLE

Eight series comprising fifty constant-rating tests were made, during which four different grades of coal were burned and four different arrangements of the boiler baffling tried out. Table I gives general data and dimensions of the equipment and Table II the names and sources of the coals, together with the quantities burned. Figs. 1, 2, 3, and 4 show respectively the four baffle arrangements; namely, the original baffle, the "A" baffle, the "B" baffle and the "C" baffle.

The tests were begun April 7, 1921, and completed Aug. 27, 1921. The full number of observations were taken until Aug. 6 only, after which date operating tests were conducted for the purpose of determining the effects of blowing flues at various intervals of time and also to obtain data on the amount of coal required for different kinds of banks. These tests were conducted with a reduced force, taking only the most essential observations. During the period from April 7 to Aug. 6 the services of 57 observers working on three 8-hour shifts were required, besides those engaged in analyzing coal and ash, and others conducting special investigations and checking methods.

The "A" baffling arrangement showed no improvement over the original arrangement except that the draft at the damper was reduced about 33 per cent. With the "B" arrangement an average increase in superheat of over 20 deg. F. was obtained and the flue-gas temperature was reduced about 70 deg. F. as compared with the original baffling. The draft was also about 38 per cent less than with the original baffling. The results obtained indicated that there was little difference between the "B" and "C" arrangements, and on account of the simplicity of the "B" baffle and the fact that a slightly higher superheat was obtained, it was decided upon as the most practical arrangement to install in the present boilers.

Comparing the average efficiencies obtained during the entire series of tests on the original baffle before washing with the average obtained during the entire series of tests on the "B" baffle arrangement, it was found that the original baffle gave 76.8 per cent at 178

*Abstract of paper read before American Society of Mechanical Engineers, New York, Dec. 4 to 7, 1922.

per cent rating and the "B" baffle 79.1 per cent at 145 per cent rating. These results include all periods between the tests of the respective series, and one starting and burning-out period.

Data on the four different coals used in the tests are given in Table II. Shipper "B" coal gave only slightly better efficiency than Shipper "A" coal, while Shipper "C" coal was about 1 per cent and Shipper "D" coal 2.5 per cent lower than Shipper "A" coal. The results obtained, however, are not directly comparable due to the different arrangements of boiler baffling and conditions of the heating surface. A comparison on the basis of combustible lost in the refuse seems to be a better method. Expressed in percentage of dry coal the loss was: Shipper "B," 1.6 per cent; Shipper "A," 2.25 per cent; Shipper "C," 3.68 per cent; Shipper "D," 4.25 per cent.

Considerable difficulty was experienced with Shipper "D" coal due to the low fusion temperature of the ash, resulting in large clinkers, so that this coal was considered unsatisfactory. The other three burned satisfactorily, so that a consideration of cost f.o.b. plant, together with the relative value as fuel, determined the most economical coal. The results in this case were slightly in favor of Shipper "B."

Table III gives the losses itemized in percentages of the total heat supplied in the coal. The loss due to combustible in refuse is based on the percentage of combustible in the refuse and is computed by assuming that the refuse lost through the stack contains the same percentage of combustible as the refuse from the ashpit. Presumably the refuse to the stack contains more combustible than was shown by the analysis of the ashpit refuse, so the losses under this heading probably are slightly under the correct values.

In the radiation and unaccounted-for losses are included radiation from the boiler setting, loss due to sensible heat in refuse, loss due to unburned gases other than CO, and all errors involved in observation and analysis. As this item is small compared with results obtained in other tests, a few words of explanation are given to show that the radiation on this type of boiler is very low. H. Kreisinger gives the radiation per square foot of exposed surface as 250 B.t.u. per hour at 100 per cent rating and 350 B.t.u. per hour at 200 per cent rating. The total exposed surface of this boiler, including steam drums, is 4,294 sq.ft., or 18.1 per cent of the water-heating surface, giving a radiation loss per hour per square foot of water-heating surface of 45.30 B.t.u. at 100 per cent rating and 63.4 B.t.u. at 200 per cent rating. The coal burned per square foot of water-heating surface per hour is practically a straight-line function between 50 per cent and 225 per cent rating, which gives 0.34 lb. per hr. at 100 per cent rating and 0.677 lb. per hr. at 200 per cent rating. This gives the radiation loss per pound of coal as 133 B.t.u. (1.06 per cent) at 100 per cent rating and 95 B.t.u. (0.76 per cent) at 200 per cent rating, assuming a coal of 12,500 B.t.u. per lb. as fired. An effort was made to check these values by computing the radiation losses on the bases of the exposed surfaces and certain temperatures, some of which were actually measured on a boiler of this type, and some assumed. Conservative values of heat-transmission coefficients were taken, with the result that the calculation gave the radiation per pound of coal as 75 B.t.u. (0.60 per cent) at 100 per cent rating and 40 B.t.u. (0.32 per cent) at 200 per cent rating. With the exception of a few tests, which were of too short duration or were otherwise unsatisfactory, the observed radiation losses did not depart from the computed radiation by more than 1.5 per cent of the heat value of the coal.

The stokers, blowers, and grinders were driven by direct-current variable-speed motors, the electrical input to which was measured by watt-hour meters. This electrical energy was all generated by the auxiliary turbo-generators, the exhaust steam from which is all utilized for heating feed water. Tests have been made which indicate a cost of 4,550 B.t.u. per kw.-hr. generated on these auxiliary turbo-generators. The steam equivalent to the electrical energy has therefore been

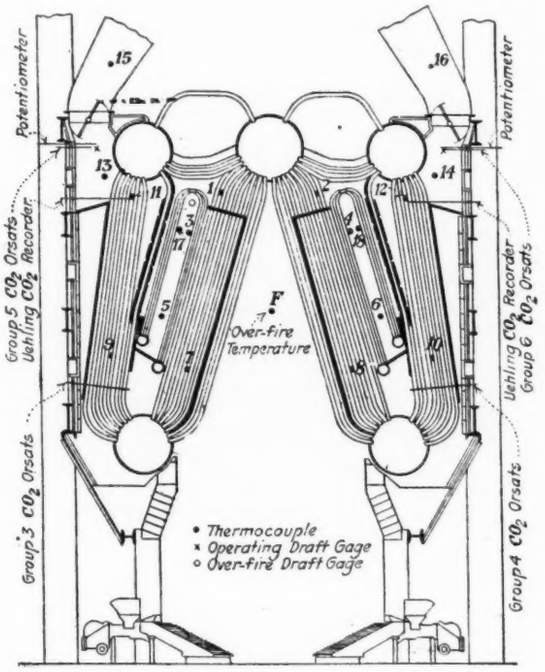


FIG. 3—"B" BAFFLE

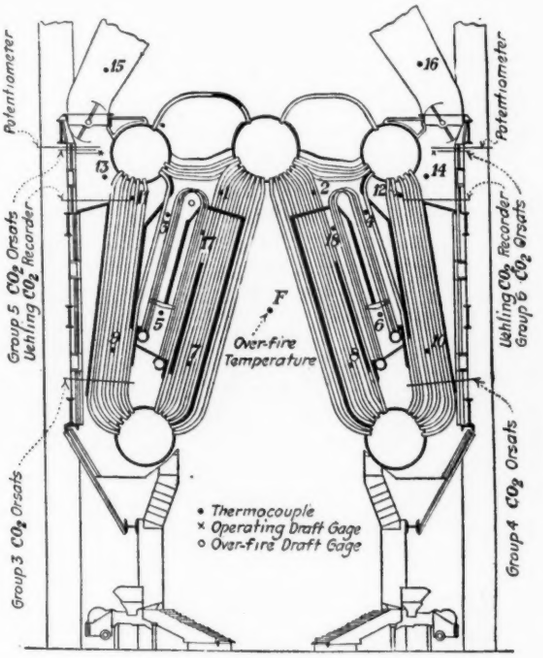


FIG. 4—"C" BAFFLE

computed on this basis and reduced to equivalent steam from and at 212 deg. Fahrenheit.

The steam required to drive the 1,200-gal.-per-min. boiler-feed pump was metered; but the pump was much larger than was needed to serve one boiler, which necessitated operating the pump at low ratings with a

TABLE I—GENERAL DATA AND DIMENSIONS OF EQUIPMENT

*Boiler:*
Type W Stirling, manufactured by Babcock & Wilcox Company. Total number of tubes, 1564; diameter, 3½ in.; 9 gage. Net effective heating surface, 23,654 sq. ft. Installed and first in operation October 25, 1920.

*Superheater:*
Twin B. & W., U-tube. Two superheaters having 102 tubes each. Tubes 8 gage, 2 in. in diameter; developed length, 24 ft. 11½ in. Total heating surface, 2996 sq. ft.

*Stoker:*
Underfeed stoker manufactured by American Engineering Company, Philadelphia, Pa. Two 13-retort, 2-ram stokers; total width, 22 ft. 10½ in.; effective length (both stokers), 32 ft. 5 in. (ashpit not considered in giving effective length). Projected grate area, 284 sq. ft. Width of ashpit, 3 ft. 11 in. Ratio of saturated heating surface to grate area, 83.4 to 1. Drive: variable-speed d.c. motors. Clinker grinders: independent drive by d.c. motors.

*Setting:*

| | |
|---|---|
| Height of mud drums above floor | 15 ft. 9 in. |
| Height from grate to top of combustion chamber | 33 ft. |
| Width of combustion chamber | 26 ft. 2 in. |
| Length of combustion chamber over grate | 16 ft. 4 in. |
| Total volume computed above grate | 8703 cu. ft. |

*Forced-Draft Fan:*
Double conoidal blower manufactured by Buffalo Forge Co. Capacity, 74,000 cu. ft. at 6.5 in. water pressure. Driven by variable-speed d.c. motor.

*Stack:*

| | |
|---|---|
| Height above center of grate | 323 ft. 6 in. |
| Inside diameter of stack at top | 15 ft. 9 in. |

Dampers at boiler are motor-operated.

correspondingly high steam consumption. From tests it has been shown that when the exhaust from normally loaded boiler-feed pump turbines was utilized for heating the feed water, the cost of pumping water was 1.7 B.t.u. per lb. of water. Expressed in equivalent steam from and at 212 deg. F. the pounds of steam per hour is then equal to 0.00175 multiplied by the pounds of water pumped per hour.

Since no relation appears to exist between the quantity of steam required for flue and soot blowing and

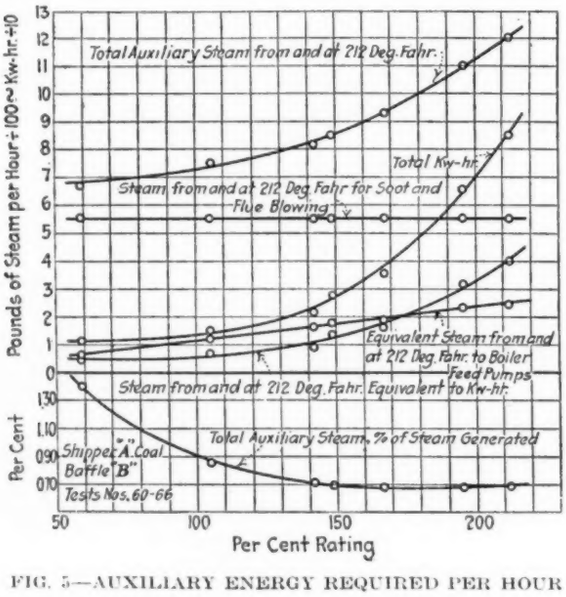
Pounds of Steam per Hour ÷ 100 or Kw-hr ÷ 10
Total Auxiliary Steam from and at 212 Deg. Fahr.
Total Kw-hr.
Steam from and at 212 Deg. Fahr for Soot and Flue Blowing
Equivalent Steam from and at 212 Deg. Fahr. to Boiler Feed Pumps
Steam from and at 212 Deg. Fahr. Equivalent to Kw-hr.
Per Cent
Total Auxiliary Steam, % of Steam Generated
Shipper "A" Coal
Baffle "B"
Tests Nos. 60-66
Per Cent Rating

FIG. 5—AUXILIARY ENERGY REQUIRED PER HOUR

the percentage rating, these quantities are taken as constant hourly quantities over the testing periods. By taking an average of the quantities of flue-blowing steam which were metered and computing the quantities for soot removal, a figure of 555 lb. per hour equivalent steam from and at 212 deg. F. was obtained as the amount required for both flue blowing and soot removal.

Fig. 5 gives for tests Nos. 60-66 the electrical energy required per hour for the blowers, stokers and grinders, the steam equivalent to the electrical energy, and the total steam for all auxiliary uses expressed as equivalent steam from and at 212 deg. Fahrenheit.

Summarizing, the total energy consumed by the boiler auxiliaries averaged about 0.7 per cent between 170 per

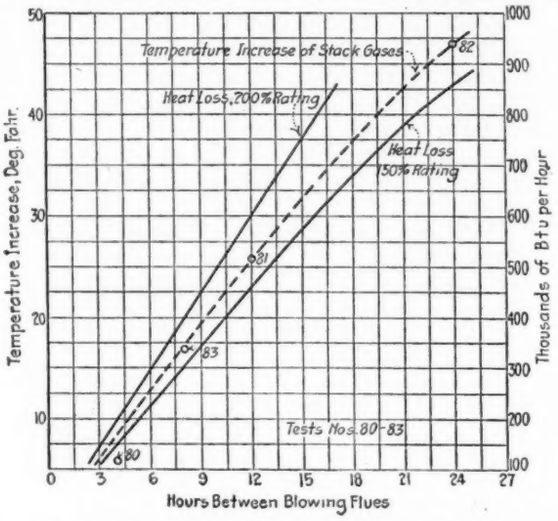
Temperature Increase of Stack Gases
Heat Loss, 200% Rating
Heat Loss 150% Rating
Tests Nos. 80-83
Temperature Increase, Deg. Fahr.
Thousands of B t u per Hour
Hours Between Blowing Flues

FIG. 6—EFFECT OF VARYING TIME INTERVAL BETWEEN BLOWING OF FLUES

cent and 200 per cent rating, while at ratings near 50 per cent the energy consumed was 1.6 per cent. These figures are based on the complete utilization of the exhaust steam in the feed-water heaters.

Four tests (Nos. 80-83) were made to determine what effect varying the time interval between blowing flues would have on the temperature of flue gas leaving the boiler. By considering only periods during which con-

TABLE II—COAL DATA

| (1) Name of Coal | (2) Location of Mine | (3) Tests | (4) Coal burned during tests of column (3), lb. | (5) Duration in hours of tests of column (3) | (6) Heating value of coal, B.t.u. per lb. |
|---|---|---|---|---|---|
| Shipper "A" | Harlan, Ky. | Nos. 3 to 18 | 6,785,888 | 613 | — |
| Shipper "A" | Harlan, Ky. | Nos. 40 to 43 | 1,744,337 | 128 | 12,510 |
| Shipper "A" | Harlan, Ky. | Nos. 60 to 66 | 2,857,053 | 242 | — |
| Shipper "A" | Harlan, Ky. | Nos. 70 to 76 | 3,271,959 | 266 | — |
| Shipper "B" | Mingo, W. Va. | Nos. 20 to 24 | 2,304,682 | 196 | 13,280 |
| Shipper "C" | Kanawha, W. Va. | Nos. 18-30 to 33 | 1,668,998 | 143 | 12,320 |
| Shipper "D" | Logan, W. Va. | Nos. 50 to 54 | 1,937,176 | 154 | 12,200 |

Averages for Whole Test:

| | |
|---|---|
| Coal per hr., lb | 11,780 |
| Water per hr., lb | 98,600 |
| Per cent rating | 145.6 |
| Apparent evaporation | 8.37 |
| Equivalent evaporation | 10.10 |
| Per cent efficiency | 77.9 |
| Weighed refuse in per cent of coal burned | 11.30 |
| Computed refuse in per cent of coal burned | 13.92 |
| Loss to stack in per cent of refuse | 18.8 |

ditions were uniform, and arranging these for each test, the following values were obtained:

| Test No. | Time Interval Between Blows | Temp. Increase, Deg. F. |
|---|---|---|
| 80 | 4 | 6 |
| 81 | 12 | 26 |
| 82 | 24 | 47 |
| 83 | 8 | 17 |

In Fig. 6 the temperature increase has been plotted against the time interval between blowing. The B.t.u. loss per hour was computed from the mean temperature increase and is also shown in the same figure for ratings of 150 and 200 per cent.

Taking into consideration the labor and maintenance costs directly influenced by the frequency of blowing flues, together with the quantity of steam required per blow, an economic balance is obtained at 12.5 hours, assuming a constant rating of 200 per cent. Boilers banked at night should be blown only once a day. The foregoing is a literal interpretation of the test results which does not indicate exactly the proper procedure, but serves more as a check on present practice.

The banking test included the period from Aug. 13 to Aug. 22. From Aug. 13 to 18, the first period, dead banks were carried at night and over Sunday, and from the 18th to the 22d, the second period, floating banks were carried nights and Sunday. During the daytime the boiler was steamed at about 157 per cent rating. In computing the coal chargeable to banking, it was assumed that all water was evaporated at the efficiency corresponding to the average rating during the steaming period. Although part of the water was evaporated at lower ratings during the building up and burning down of the fire, the resulting lower efficiencies during these periods are considered as chargeable to banking. These tests were conducted while the boiler was baffled according to arrangement "C." The results of these tests have been plotted in Fig. 7 and straight lines have been drawn through the points representing the two methods of banking. It seems probable that a straight line does not represent the true relation between the two variables, but the lack of sufficient data makes the determination of the exact relationship impossible.

TABLE III—HEAT BALANCE

| Test No. | % Rating | Heat absorbed by boiler | Loss due to moisture in coal | Loss due to hydrogen | Heat Lost to Stack in | | | | Loss due to incomplete combustion | Loss due to combustible in refuse | Radiation and unaccounted for | B.t.u. in coal as fired |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Theoretical dry gas | Excess dry air | Moisture in air | Total | | | | |
| 2 | 116.0 | 77.9 | 0.3 | 4.5 | 8.9 | 3.0 | 0.2 | 12.1 | 0.5 | 1.9 | 2.8 | 12690 |
| 3 | 133.0 | 78.3 | 0.4 | 4.8 | 9.5 | 3.7 | 0.1 | 13.3 | 0.6 | 1 9 | 0.7 | 12650 |
| 4 | 148.5 | 81.2 | 0.5 | 3.9 | 9.7 | 3.9 | 0.2 | 13.8 | 0.6 | 2 0 | -2.0 | 12425 |
| 5 | 163.7 | 78.9 | 0.5 | 4.5 | 10.1 | 3.2 | 0.2 | 13.5 | 0.4 | 1.8 | 0.4 | 12750 |
| 6 | 182.0 | 77.3 | 5.6 | 4.3 | 10.9 | 3.4 | 0.1 | 14.4 | 0.4 | 3 0 | -0.03 | 12550 |
| 7 | 199.0 | 79.8 | 0.6 | 4.5 | 11.7 | 2.7 | 0.1 | 14.5 | 0.7 | 2 3 | -2.4 | 12277 |
| 8A | 215.0 | 75.4 | 0.7 | 4.4 | 12.0 | 3.0 | 0.2 | 15.2 | 0 6 | 3 0 | 0.7 | 12432 |
| 8B | 210.0 | 74.4 | 0.5 | 4.4 | 11.8 | 4.1 | 0.2 | 16.1 | 0.7 | 3.0 | 0.9 | 12595 |
| 9 | 241.0 | 75.4 | 0.7 | 4.4 | 12.1 | 2.6 | 0.2 | 14.9 | 0 5 | 1 9 | 2.2 | 12550 |
| 10 | 268.0 | 75.2 | 0.6 | 4.6 | 13.0 | 2.9 | 0.3 | 16.2 | 1.1 | 1.2 | 1.1 | 12540 |
| 11B | 79.0 | 75.8 | 0.5 | 4.1 | 7.2 | 5.1 | 0.3 | 12.6 | 0.5 | 1.8 | 4.7 | 12780 |
| 12 | 102.8 | 78.1 | 0.6 | 4.3 | 7.1 | 5.0 | 0.2 | 12.2 | 0.5 | 3.1 | 1 1 | 12563 |
| 13 | 53.2 | 76.0 | 0.4 | 4.3 | 7.0 | 6.6 | 0.2 | 13.8 | 0.6 | 2.3 | 2 6 | 12860 |
| 14 | 126.2 | 83.1 | 0.6 | 4.0 | 8.2 | 2.1 | 0.1 | 10.4 | 0.4 | 1.8 | -0.3 | 12580 |
| 15 | 154.5 | 80.3 | 0.4 | 4.2 | 8.9 | 2.6 | 0.2 | 11.6 | 0 4 | 3 8 | -0 8 | 12677 |
| 16 | 180.0 | 80.5 | 0.4 | 4.0 | 9.8 | 3.1 | 0.2 | 13.1 | 0.2 | 2.6 | -0.8 | 12425 |
| 17 | 67.4 | 79.5 | 0.5 | 3.9 | 7.2 | 5.0 | ... | 12.2 | 0.5 | 2 1 | 1.3 | 12730 |
| 18 | 216.7 | 80.5 | 0.3 | 4.0 | 10.6 | 2.8 | 0.2 | 13.6 | 0.3 | 2.9 | -1.6 | 12690 |
| 20 | 108.4 | 79.0 | 0.4 | 4.1 | 8.1 | 4.2 | 0.2 | 12.5 | 0.5 | 2.0 | 1.7 | 13100 |
| 21 | 153.3 | 78.3 | 0.4 | 3.6 | 9.1 | 4.0 | 0.1 | 13.2 | 0.4 | 1 4 | 2.7 | 13280 |
| 22 | 193.8 | 79.9 | 0.4 | 4.7 | 9.6 | 1.8 | 0.1 | 11.5 | 0.5 | 1.7 | 1 2 | 13220 |
| 23 | 224.9 | 78.1 | 0.3 | 4.3 | 11.2 | 1.9 | 0.2 | 13.3 | 0.6 | 1.5 | 1 8 | 13330 |
| 24 | 145.4 | 80.0 | 0.3 | 4.2 | 7.7 | 4.3 | 0.2 | 12.2 | 0.4 | 1.6 | 1.3 | 13540 |
| 30 | 151.4 | 78.8 | 0.4 | 4.0 | 9.1 | 2.9 | 0.2 | 12.2 | 0.4 | 3.5 | 0.7 | 12305 |
| 31 | 115.0 | 78.6 | 0.3 | 4.2 | 8.4 | 2.6 | 0.2 | 11.2 | 0.2 | 4.0 | 1.5 | 12283 |
| 32 | 184.1 | 75.6 | 0.4 | 4.1 | 9.8 | 2.4 | 0.3 | 12.5 | 0.3 | 2.6 | 4.5 | 12300 |
| 33 | 216.5 | 77.1 | 0.3 | 3.8 | 10.8 | 2.7 | 0.3 | 13.8 | 0.3 | 4.1 | 0.6 | 12390 |
| 40 | 153.5 | 77.9 | 0.5 | 4.3 | 10.2 | 3.9 | 0.2 | 14.3 | 0.3 | 3.3 | -0.6 | 12240 |
| 41 | 199 0 | 76.7 | 0.5 | 4.5 | 11.5 | 3.7 | 0.3 | 15.5 | 0 2 | 3.1 | -0 5 | 12580 |
| 42 | 225.8 | 72.9 | 0.4 | 3.9 | 12.5 | 3.4 | 0.3 | 16.2 | 0.4 | 3.6 | 2.6 | 12813 |
| 43 | 108.0 | 77.3 | 0.5 | 4.2 | 9.3 | 6.2 | 0.2 | 15.7 | 0.5 | 4.1 | -2.3 | 12357 |
| 50 | 106.1 | 77.5 | 0.5 | 4.2 | 9.2 | 6.6 | 0.2 | 16.0 | 0.3 | 4 8 | -3.3 | 11913 |
| 51 | 137.0 | 76.0 | 0.5 | 4.3 | 9.8 | 4.4 | 0.2 | 14.4 | 0.2 | 3.6 | 1.0 | 12072 |
| 52 | 163.6 | 75.0 | 0.4 | 3.7 | 10 9 | 4.3 | 0.3 | 15.5 | 0.2 | 4.6 | 0.6 | 12380 |
| 53 | 194.3 | 76.0 | 0.3 | 4.3 | 10.9 | 2.6 | 0.3 | 13.8 | 0.3 | 4.7 | 0.6 | 12530 |
| 54 | 226.4 | 70.9 | 0.4 | 4.1 | 12.4 | 2.5 | 0.4 | 15.3 | 0.5 | 7.3 | 1.5 | 12260 |
| 60 | 196 4 | 78.5 | 0.5 | 4.1 | 9.8 | 1.6 | 0.3 | 11.7 | 0.4 | 4.3 | 0.5 | 12200 |
| 61 | 168.4 | 77.0 | 0.4 | 4.1 | 8.8 | 1.7 | 0.4 | 10.9 | 0.4 | 3 1 | 4.1 | 12445 |
| 62 | 142.0 | 81.7 | 0.5 | 4.5 | 8.3 | 1.4 | 0.2 | 9.9 | 0.4 | 2.5 | 0.5 | 12240 |
| 63 | 106.2 | 83.5 | 0.5 | 3.9 | 7.0 | 1.7 | 0.2 | 8.9 | 0.4 | 2.7 | 0.1 | 12261 |
| 64 | 59.0 | 80.9 | 0.3 | 4.2 | 6.1 | 3.3 | 0.2 | 9.6 | 0.1 | 2.8 | 2.1 | 12549 |
| 65 | 148.5 | 80.8 | 0.4 | 4.7 | 8.0 | 1.1 | 0.3 | 9.4 | 0.4 | 3.8 | 0.5 | 12220 |
| 66 | 212.5 | 75.8 | 0.4 | 3.8 | 10.3 | 1.5 | 0.3 | 12.1 | 0.4 | 5.6 | 1.9 | 12290 |
| 70 | 190.0 | 80.4 | 0.3 | 3.7 | 8.5 | 2.0 | ... | 10.5 | 0.4 | 4.4 | 0.3 | 12730 |
| 71 | 162.0 | 81.3 | 0.4 | 3.6 | 7.8 | 2.2 | 0.4 | 10.4 | 0.4 | 3.3 | 0.6 | 12340 |
| 72 | 134.0 | 82.0 | 0.5 | 3.7 | 7.4 | 1.9 | 0.4 | 9.7 | 0.4 | 3.3 | 0.4 | 12149 |
| 23 | 105.3 | 82.2 | 0.3 | 3.6 | 6.3 | 1.8 | 0.2 | 8.3 | 0.3 | 2.6 | 2.7 | 12550 |
| 74 | 149.0 | 82.4 | 0.6 | 3.8 | 7.7 | 2.3 | 0.2 | 10.2 | 0.3 | 2.1 | 0.6 | 12118 |
| 75 | 183.2 | 79.8 | 0.6 | 3.7 | 8.8 | 2.2 | 0.2 | 11.2 | 0.3 | 2.7 | 1.7 | 12410 |
| 76 | 208.5 | 75.6 | 0.5 | 3.6 | 8.6 | 2.0 | 0.3 | 10.9 | 0.4 | 3 2 | 5.8 | 12650 |

Expressed in equation form, the coal required for the two methods of banking is:

*For floating bank, lb. coal* $= 8{,}600 + 105x$

*For dead bank,* *lb. coal* $= 8{,}000 + 280x$

where $x$ is the number of hours banked. These equations give a greater amount of coal for a floating bank than for a dead bank for periods of less than four hours; but under actual conditions there is practically no difference between the two kinds of banks for the first portion of a banking period, so the equations are meant to apply only to banking periods in excess of four hours.

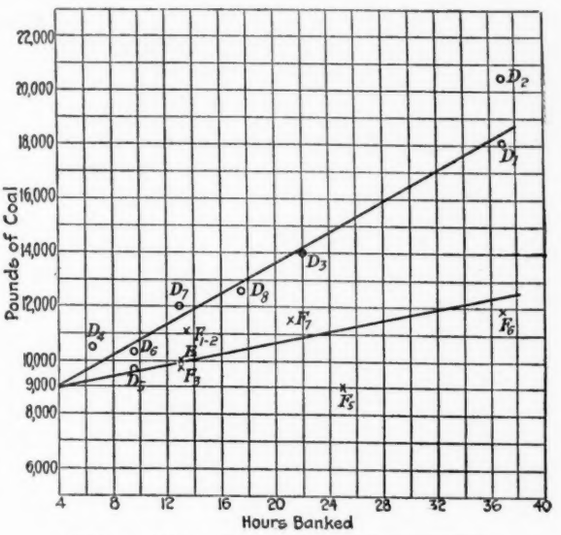


FIG. 7—COAL REQUIRED FOR BANKING

At the present writing seventeen boilers have been rebaffled according to arrangement "B," modified slightly in the arrangement of the cross-baffle at the top of the front baffle. The vertical baffle has been shortened about 6 in. and the cross-baffles at the top inclined upward at about 35 deg. from the front baffle. The results being obtained indicate that the superheated-steam temperature has been increased fully 50 deg. F. over that obtained with the original baffle, and that there is a decided improvement in the over-all efficiency.

A study of the heat absorbed in the different passes of the boiler indicated that a rearrangement of tubes would be beneficial. This possibility was studied by the engineers of the Babcock & Wilcox Co. and the Detroit Edison Co., with the result that the new boilers recently installed at the Marysville power house have in cross-section but five tubes between the upper center drum and each mud drum and ten tubes between each mud drum and the upper drum directly above. The boiler is baffled similarly to arrangement "B," except that there are two vertical baffles in each rear bank which direct the gases in three vertical passes after they leave the superheater pass. Economy results are not yet available, but it is believed that a decided decrease in the stack-gas temperatures will be realized.

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It is a fundamental principle of practical furnace design and operation that the gases should not come in contact with the boiler tubes or other relatively cold surfaces until combustion is complete.

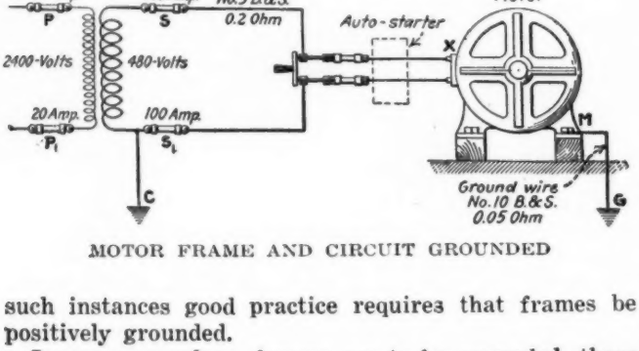
# Why Ground Connections Should Be Well Made

## The Danger of Haphazard Grounding—Ground Circuit Should Have Low Resistance To Furnish Desired Degree of Protection and Large Carrying Capacity To Prevent Burnout—Necessity of Good Ground in Case of Transformer Breakdown

BY EDGAR P. SLACK
Assistant Engineer, Underwriter Laboratories

A MOTOR whose frame is neither effectively grounded nor effectively insulated has the disadvantages of both the grounded frame and the insulated frame without having the advantages of either. Although for motors rated below 150 volts the National Electrical Code contains no definite requirements covering this feature, it is always better, from the fire and accident prevention viewpoint, either to ground the frame positively or else to insulate it positively from the ground.

One of the dangers of haphazard grounding is that if a breakdown occurs, making the frame alive, the leakage current, having no ready path to ground, may jump from the frame to some near-by grounded point, producing a spark or arc and possibly causing fire. In extra-hazardous locations, where inflammable or explosive dust or vapors are present, the slightest spark might cause a serious fire or explosion, and in




MOTOR FRAME AND CIRCUIT GROUNDED

such instances good practice requires that frames be positively grounded.

In any case where frames are to be grounded, there are two principal reasons why the grounding should be permanently and effectively done—to give the desired degree of protection against shock, and to prevent burnout. These points may be illustrated by considering the case shown in the figure.

An induction motor rated at 50 amperes and controlled by an autostarter, is operated on a 480-volt circuit from a transformer, as shown. The supply line is No. 3 B. & S. gage; $S$ and $S_1$ are 100-ampere fuses under Table C of Rule 18 of the Code; and the primary fuses $P$ and $P_1$, to give equivalent protection, are rated 20 amperes. The size of the ground conductor is determined by the size of the fuses $S$ and $S_1$; these being not over 100 amperes, the ground wire is No. 10 B. & S. gage. The supply circuit will be assumed to have a resistance of 0.2 ohm per line from $S$ to $X$, the ground wire 0.05 ohm from $M$ to $G$ and the resistance of the circuit ground at $C$ 1 ohm. The diagram is intended for a four-wire two-phase circuit with only one circuit shown for simplicity.

Suppose, now, a dead ground to occur on the motor at the point $X$, and study the effect produced, first, if the grounding of the frame were well done, and second, if it were imperfectly done.

With the ground wire connected properly to a water-piping system, the resistance of the ground connection at $G$ may be taken as 0.1 ohm, a value that it will not generally exceed. The total resistance to the flow of current to ground from $S$, along the line $SX$, through the ground $X$ to the motor frame, then along the ground wire $MG$, into the ground at $G$, and back through $C$ will then be $0.2 + 0.05 + 0.1 + 1$ or 1.35 ohms, and the corresponding current, that would tend to flow would be $480 \div 1.35$, or about 356 amperes, which would promptly blow the fuse at $S$. It should be noted that the blowing of this fuse makes the motor frame dead.

### RESULTS OF HAPHAZARD GROUND CONNECTION

Now compare these results with those obtained under the same conditions of breakdown in the motor, but with the ground connection at $G$ poorly made and having a resistance of, say, 10 ohms, which is high for a water-pipe ground. The resistance to the flow of leakage current is now $0.2 + 0.05 + 10.0 + 1$ or 11.25 ohms, and the current flow corresponding will be $480 \div 11.25$, or 42.7 amperes. This current will not be sufficient to blow the 100-ampere fuse at $S$, and the motor frame will remain alive, at least until the circuit burns open at some point. The point where the circuit is most likely to open is at the high-resistance ground, that being the point where the most heat is developed. The heat generated at this ground connection is equal to the square of the current times the resistance, equals $(42.7)^2 \times 10$, or 18,230 watts (18.2 kw.), which would probably burn the ground connection off and leave the frame connected to the live side of the supply line and at a potential of approximately 480 volts to ground.

A comparison of these two cases shows that with the frame well grounded the flow of current was sufficiently large to blow the fuse in the supply line, promptly clearing the circuit and leaving the motor frame dead. But with the frame poorly grounded under the same conditions, the ground connection became seriously overheated and probably burned off, with the possibility of starting fire and of leaving the frame permanently connected to the supply line and at a dangerous potential.

It may further be noted that with a certain resistance in circuit the current flow in the ground wire might be as great as 110 amperes without blowing the 100-ampere fuse at $S$, and that if this current were to persist for any length of time it would result in considerable overheating of the ground wire $MG$. This wire has a rating

of 25 amperes; the insulation would smoke at about 75 amperes; and 110 amperes, if continued, would probably burn it out. The case chosen represents the extreme limit allowed and is intended to show why ground wires smaller than No. 10 are not permitted, the likelihood of burnout being too great.

In case the supply transformer fails by a cross between the primary and secondary windings, allowing the high primary voltage to be impressed on the motor circuit, the insulation of the motor is likely to be punctured, making the frame alive. A consideration of this case along the lines mentioned, will show that under this condition also a low-resistance ground for the frame is even more necessary to keep the potential of the frame at a low value. Transformer breakdowns involve much higher voltages than secondary failures, but on the other hand have an added feature of protection in that the primary fuse *P* is in the path to ground and, being of low rating, may be expected to blow readily, clearing the circuit.

## Why an Oil Engine Ran Away

By S. M. Howe

To have a steam engine run away is not unheard of, and if there is not a quick-closing steam valve, a high speed may be reached before the throttle valve can be screwed closed. In case of an oil engine it would at first thought seem impossible for a Diesel engine to reach any great speed before the engineer could shut off the oil line.

Not so long ago I was ordered to visit a plant where it was reported that the engine could not be held down at anything less than full load. On my arrival, I found a Diesel of an old type. The engineer, who was apparently pretty well acquainted with oil engines, stated that recently every time he started the engine it would speed up and refuse to stop even though the oil line to the pump was closed off. All that could be done was to excite the generator hurriedly and throw on the load. Fortunately, there was a large squirrel-cage motor driving the water-works pump that helped to make a load. The engineer reported that after racing awhile with the load, the engine would finally slow down and would stop unless the fuel-line valve and the injection air valve were opened. On the other hand, if these valves were opened, the engine would come up to speed and run along nicely the rest of the night.

During the day we went over the engine, and as far as could be seen everything was in good shape. I had at first judged that lubricating oil was being thrown up into the cylinder from the crankcase and so furnishing fuel, even though the fuel and air lines were shut off. This has occurred on engines when the piston rings are badly worn and the oil level kept fairly high. However, the compression was good, indicating that the rings were tight.

It was impossible to detect the trouble until the engine was started up, and in view of the story of the running away, a load that could be thrown on if the speed did run high was highly desirable.

Toward evening the engineer made his preparations and after priming the full lines, closed the bypasses and gave the fuel pump a few more strokes for luck. He then turned on the injection air and opening the air-starting valve, kicked the engine over. The cylinders began firing at once and the engine came up to speed. The engineer built up the exciter voltage and threw in the generator switch. Somehow the exciter switch opened; probably the engineer in his haste had failed to close it correctly.

At any rate the load was lost and the engine kept on speeding up, the governor sleeve going to its overspeed position. This cut out the fuel supply, but the speed kept right on going up. I jumped to the fuel-line valve and closed it so that absolutely no oil could reach the pump and spray valves. Since there was bound to be a little oil in the fuel valve, I closed the air-injection valve, but the engine ran right along; the speed looked to me to be at least 400 r.p.m., although the rated speed was 165 r.p.m. I will admit that I was scared.

Time was precious, and I figured my life to me was just as valuable, so I had to think fast. I rushed to the spray valve bypasses and pulled them open, emptying the spray valve. Instead of a small dribble the oil came out in a rush. The engine finally slowed down and at last stopped.

Now all who are acquainted with Diesel engines will admit that this was mysterious. Normally, there is only enough fuel in the line to the spray valves to supply one charge. It seemed unreasonable that, even after shutting off the oil line, the engine kept right on firing.

While the engineer was barring the engine over to be ready for a second try, I went into a brown study. I could not see for the life of me the reason for this running away. Finally, I decided to start the engine myself and see what would happen. So I turned the fuel-pump crank until the oil showed up at the bypass valves, closed these bypasses, went to the air bottles and turned on the injection air. Next I gave the pump crank a few turns to see if the air pressure was on the fuel-valve line. Finally, I opened the starting valve and the engine turned over, ran up to speed and the governor sleeve coming up into action, the speed was held constant. The load was thrown on after a few minutes of running and nothing happened.

### Why the Difference in Action?

The question is, "What was the reason for the difference in action when the engineer started the engine and when I started it?" The explanation of part of it was simple. It was quite evident that the engine was getting oil even though the oil line was cut off. Why this was possible was not so evident. After talking to the engineer, I found that the check in the air-line check valve had been removed to be reground, and in the hurry of getting the engine ready the check had been left out. The fuel tank was about three feet above the fuel valve. This allowed the oil to flow into the fuel valve and into the air line until the opening of the air bottle put air pressure on the line. When the engine started up, the oil in the air line was forced back into the fuel valve and into the engine cylinder even though the governor prevented the pump from delivering any more oil. There was, then, no regulation of the oil going into the cylinders. The engine speeded up until the air line was either empty or until the expansion of the air lowered its pressure below the cylinder compression pressure.

When I started the engine, I turned on the injection air before I pumped up any of the oil and so the air line was not flooded with oil.

The air check was replaced and the advantage of turning on the air before pumping up the oil was explained to the operator. He agreed that I was right and said that he had originally always proceeded in this way, but that for some reason, he could not explain why, the procedure had been altered unwittingly.

**A DISCUSSION of the effect of exhaust pressure on cylinder scavenging; advantages of regulated pressures influence of pipe length on fuel consumption.**

# Exhaust Piping for Semi-Diesel Engines

BY H. F. SHEPHERD

FAR more often than is suspected, the evil that brings about the symptoms of overload in an oil engine is improper exhaust conditions; not back pressure necessarily but, more frequently, periodic waves of pressure in the exhaust pipe occurring in such relation to the valve timing as to be unfavorable. It is possible for an engine improperly scavenged to show at part load the sounds, temperatures and characteristics of full-load operation. Once the seriousness of the influence of the exhaust piping is firmly established, locating a bad condition is not so difficult. It is especially simple in the case of the four-stroke-cycle engine, as one may depend upon the indicator diagnosis entirely.

In dealing with two-stroke-cycle engines it is rather more a matter of experiment, with the indicator acting only as an aid. The influence of bad exhaust conditions operates most seriously against two-stroke-cycle engines

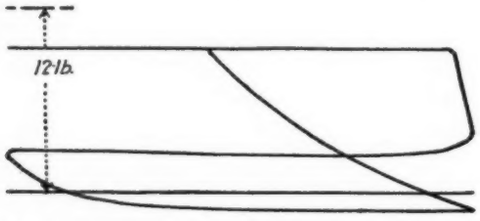



FIG. 1—EFFECT OF EXHAUST BACK PRESSURE

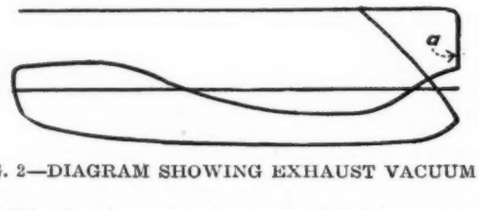



FIG. 2—DIAGRAM SHOWING EXHAUST VACUUM

and possibly least seriously against high-compression engines such as the Diesel, especially when there is very little overlap between the opening of the inlet valve and the closure of the exhaust valve. Some builders, however, prefer a valve setting that causes the inlet and exhaust valves to remain open together about the head center for a period of upward of 60 deg. This was the setting of the Hornsby-Akroyd hot-bulb engine, and later the Franchetti engine (inlet opened 25 deg. before dead center, exhaust closed 30 deg. after dead center). It is employed by Crossley's (inlet open 30 deg. before dead center, exhaust closes 30 deg. after dead center) and the writer has twice by exhaustive tests established the advantages of a considerable overlap. It would seem, then, that the overlap should not be abandoned to meet the possibility of bad exhaust conditions, but rather that the correct exhaust condition should be established.

It is one of the traditions of the trade that, given a proper length and diameter of exhaust pipe, the departing volume of discharged gases will produce a vacuum in its wake that may be utilized to induce a draft of fresh air through the inlet valve, sweeping out the clearance volume that would otherwise remain unscavenged. Every gas-engine man knows that such a vacuum is produced. In the old days he noticed the clatter of the automatic inlet valve and the re-aspiration of discharged gases at the end of the exhaust pipe. What too many have failed to realize is that the inertia

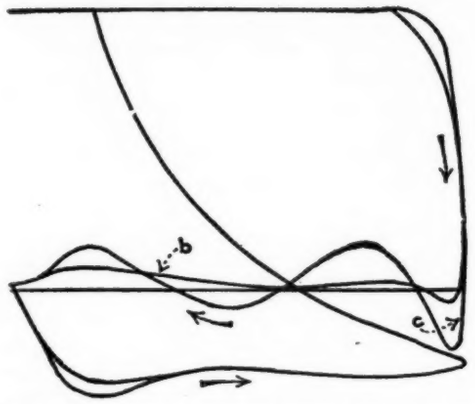



FIG. 3—INDICATOR SPRING VIBRATIONS CAUSED WAVY LINES

of the column of gases in the exhaust pipe may not always be helpful. It may be present, but if not properly timed it can be very harmful. The motion is a periodic one, the first wave being forced by the discharge from the cylinder, after which the gases remaining in the pipe oscillate a number of times, producing alternately vacuum and pressure at the engine exhaust valve or port. The number of such oscillations is dependent upon the length and diameter of the exhaust pipe and the location and size of the exhaust pot.

In support of these facts the accompanying indicator diagrams are offered. Fig. 1 was taken with a light spring from an old Hornsby-Akroyd engine. It exhibits

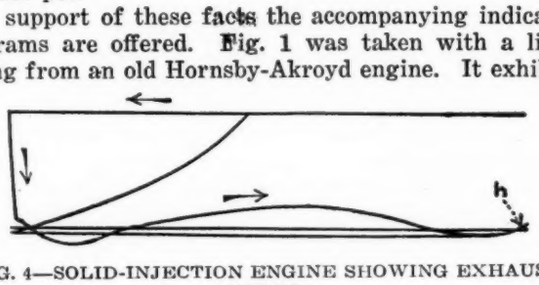



FIG. 4—SOLID-INJECTION ENGINE SHOWING EXHAUST SURGES

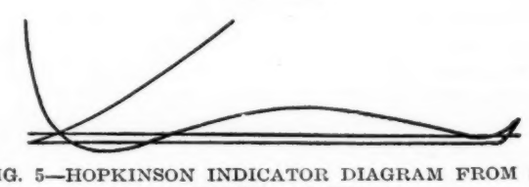


FIG. 5—HOPKINSON INDICATOR DIAGRAM FROM SAME ENGINE AS FIG. 4

no wave in the exhaust line, and little wonder, for in the exhaust system were a pot, a water heater and a muffler. This is a clear and simple case of back pressure, all oscillation being damped out in the pipe. Its exhaust valve was set to close after dead center for the reason that it was desired to re-aspirate a certain amount of exhaust gas at light loads when the air

charge heat would be insufficient to maintain the vaporizer temperature. As will be shown later it is always possible to do this and at the same time to scavenge fully at full load without altering the valve setting. As indicated by the diagram, however, the engine, owing to the constant back pressure, undoubtedly re-aspirated its full portion of the exhaust gas even at full load.

FIG. 6—EXHAUST DIAGRAM OF BESSEMER ENGINE

FIG. 7—DIAGRAM WHEN A STOP WAS USED

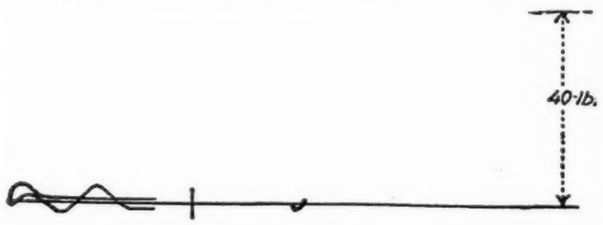



FIG. 8—DIAGRAM WITH EXHAUST PIPE DIFFERENT FROM FIGS. 8 AND 9

Fig. 2 is a diagram from an old Otto engine of the crosshead type. It shows evidence of a vacuum during the exhaust stroke which is effective in reducing the back pressure to a mean of almost zero, yet the period oscillation in the pipe is so short that at dead center, when it would be desirable to scavenge the clearance, there is a pressure condition in the exhaust system instead of a vacuum.

In considering these diagrams, great care must be exercised to avoid mistaking waves due to indicator inertia for those due to pressure. Fig. 3 was taken from a small Foos engine. If one of the two exhaust lines were taken at its face value, it might well be assumed that there were violent oscillations in the exhaust pipe. But this is clearly a case of indicator vibrations as evidenced in the first place by the line *b* and further evidenced by the point *c*, which is clearly overtravel of the indicator spring and pencil. Whether wave lines are brought about by pressure or indicator vibration can usually be determined by changing the spring. With a heavy spring the vibrations may disappear entirely if not due to pressure or they will be of very much shorter period, showing a greater number of waves. Fig. 4 was taken from an engine built by the writer and working on a modification of the Guenther and Crossley principles. The point *h* indicates the undesirable resurge of the exhaust into the clearance at the time when both suction and exhaust valves are open. There was room for suspicion, however, that the delicate line might be the resultant of superimposing the wave due to the indicator period upon that due to oscillations in the exhaust pipe. The indicator used was the American-Thompson, which with light springs has a slow period. To learn something further of this, the diagram in Fig. 5 was taken with a Hopkinson flash-light indicator. There is a slight difference in the diagrams, yet the evidence of the undesirable condition remains, confirming the indication of the Thompson instrument. The exhaust pipe of a Bessemer engine gave the diagram shown in Fig. 6. When the ports opened at *i*, a rise of pressure took place almost immediately in the pipe, to be succeeded by a drop to vacuum before dead center, and by further oscillations continuing until the next discharge. Again, there was some doubt as to whether or not the vacuum loops indicated actual vacuum or natural vibration of the indicator resulting from the sudden movement after *i*. A stop was accordingly placed in the indicator limiting the piston to movements under vacuum only, and the diagram in Fig. 7 was taken, confirming the indication of the instrument.

As opposed to Figs. 6 and 7 is shown Fig. 8, taken from an identical engine with different exhaust piping. The waves beyond the open period of the ports are cut out of the tracings as they are too delicate to reproduce. Fig. 6 shows a bad condition, as there is pressure within the cylinder at the time the scavenging ports opened. The scavenging air enters upon a falling cylinder pressure which results in air being carried out of the exhaust ports. The diagram in Fig. 8 is far more favorable though it still leaves something to be desired.

Very frequently, surges in the exhaust pipe, like Fig. 6 for instance, or even Fig. 8 in some degree, will produce cylinder diagrams with an indication of insufficient transfer port when really the fault lies in the exhaust system. This may be turned to advantage at times. Most moderate compression semi-Diesel engines lack heat to insure vaporization at light loads. A variety of compromises is in use, yet one of the simplest may be effected by so arranging the exhaust piping that the vacuum following the outgoing exhaust assists the introduction of the air charge at full load, while with the lesser force of exit at no load the air charge is not completely transferred. Thus the diagrams in Figs. 9 and 10 were taken from the scavenging pump of the same Bessemer engine with the same exhaust system but under different loads. In Fig. 9 the engine

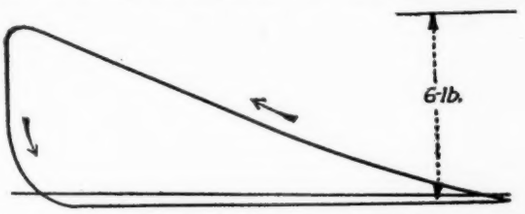



FIG. 9—SCAVENGING DIAGRAM OF BESSEMER ENGINE

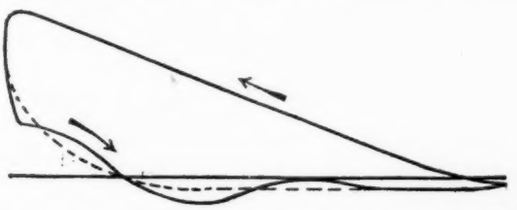


FIG. 10—SAME ENGINE AS FIG. 9, BUT AT NO LOAD

is carrying the full load and all the charge is transferred, while in Fig. 10 the engine is carrying only the drag of a loose brake. A De LaVergne type *D.H.* Semi-Diesel yielded the diagrams in Figs. 11 and 12; the diagrams in Fig. 11 were with one system of exhaust piping, those in Fig. 12 with another. This engine uses a large overlap of inlet and exhaust valve open-

ings. Its compression is moderate, and some arrangement is necessary to supply heat at a low load factor. Note, then, how much more desirable is the condition shown in Fig. 11 for light load operation than that shown in Fig. 12. Neither exhaust system is sufficiently abnormal to attract attention, and in both cases the full-load condition is good. It might be said that in the entire foregoing series of diagrams no apparent abnormal exhaust condition has been included. Yet note the

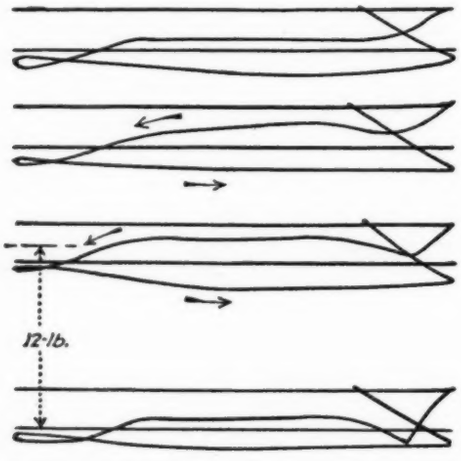



FIG. 11—DE LA VERGNE ENGINE DIAGRAMS

range of results, and these diagrams are but a few selected from hundreds that the writer has preserved for his own records.

If the matter of exhaust piping has reached a scientific basis so that a system may be designed for best results without experiment, the theory has at least not been published. The variations of effect with comparatively minor changes are so infinite in number and the normal or conventional exhaust arrangements so often wrong, that it would seem that the only certain way to insure the expected results in the field would be to submit an exhaust-pipe layout suiting local conditions and test the engine with this system in use.

Thus far only the faults revealed by an indicator have been considered. An indicator, unfortunately, is not owned by the average small-plant owner. He does very certainly, however, have a keen appreciation of anything that affects fuel economy or engine capacity. Consider the following series of tests on a small two-stroke-cycle engine:

| Exhaust Arrangement | Fuel Per Brake Horsepower Hour, Lb. | Exhaust Temperature, Deg. F. |
|---|---|---|
| 12-ft. pipe direct to large main | 0.60 | 550 |
| 9 ft. of 6-in. pipe joined by flanges to 41 ft. of 8-in. pipe, no pot or silencer | 0.64 | ... |
| 9 ft. of 6-in. pipe, exhaust pot (about 6 cylinder volumes) and 41 ft. of 8-in. pipe | 0.95 | ... |
| 3 ft. of 6-in. pipe, pot, 40 ft. of 8-in. pipe | 0.76 | 660 |

From this it is clear that the exhaust from a two-stroke-cycle engine should pass from a short pipe length or nozzle direct to a main or pot of great capacity from which the outlet is practically unrestricted. The proper length of this nozzle, the writer has found for engines running from 250 to 300 revolutions, is from 12 to 20 ft. If either very short or very long, bad results will follow. The pipe should be about half the cylinder diameter. It will also be noticed that the effect of the pot in damping out useful oscillations or pressure in the exhaust pipe is more disastrous when the pot is placed 9 ft. from the engine than when it is placed 3 ft. from the engine, and from these tests it was concluded that if the nozzle leading directly from the engine is of the proper diameter and length, it may be followed by 40 or 60 ft. of pipe two-thirds the cylinder diameter without appreciable influence. The exhaust pot and the silencer, if desired, may be installed at the very end of the system with equal results in the way of silencing and far better economy.

It is evident that an engine can handle only a certain fixed quantity of fuel depending on its oxygen supply. For instance, an engine that works effectively on six-tenths of a pound of fuel per hp., at 35 hp. is capable of burning effectively 21 lb. of fuel per hour. If the fuel consumption rises to three-quarters of a pound by reason of some adverse condition, the oxygen capacity of the engine is used up at 28 hp. and anything beyond this will present the heat symptoms of overload. Therefore, the capacity of the engine is much reduced by an increase in unit fuel consumption.

Four-stroke-cycle engines are not affected so seriously, yet matters of 10 and even 20 per cent in fuel consumption are encountered and very frequently all overload capacity is lost. Years ago the writer witnessed several distressing plant failures in which he had no interest whatever, other than a certain feeling that a very good engine designed by a highly respected engineer had fallen down for the simple reason that the installation exhaust conditions were not equal to the test-block conditions. It is to be hoped that manufacturers will bestow more attention on the design of exhaust systems and experimental data will be accumulated and published. Also that purchasers will be willing to spend more money on this most vital part of

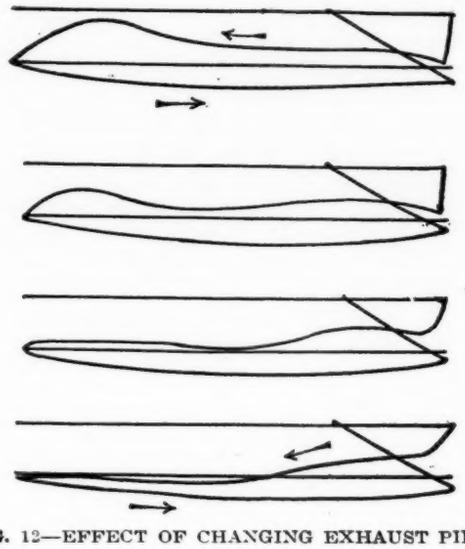


FIG. 12—EFFECT OF CHANGING EXHAUST PIPING

the installation. Further, we hope that some operators may be induced to study and better their plant conditions through this article.

By all means let the indicator be applied as close to the engine as possible. The gas movements in the pipe are wave movements varying in pressure along the pipe. In indicating the exhaust pipe for its effect upon the engine operation, we are most concerned with its pressure fluctuations right at the exhaust valve. Every plant should have an indicator for such work. It costs less than a good gun, and it affords great sport with no closed season.

# Repairing a Damaged Ammonia Compressor

By V. H. Cox*

Some months ago the head-end discharge valve of a 17x24-in. steam-driven Arctic ice machine began to make a queer rattling sound, and during that evening the suction pressure mounted slowly and the head pressure dropped. Ice was needed badly, and it was thought best to keep the machine at work until midnight and then shut down for an inspection of the valve. The writer dropped in about midnight and, noticing the back pressure up to 35 lb., ordered the machine pumped out at once. The stop valve on the suction line at the compressor leaked so badly that the valves on the suction lines at the ice-freezing tanks were closed. When about 5 lb. gage pressure was reached, the damaged valve clattered badly and then suddenly quieted, but the machine seemed to labor badly. The speed at this time was 40 r.p.m. and was further reduced to 20 r.p.m. and no more trouble was experienced until zero gage pressure was reached. At this point, from the sound of the machine, it seemed to be pumping very wet gas, and then the valve apparently jammed in its seat. The engineer at once closed the throttle of the engine, and as the piston came back toward the head end of the compressor, it must have caught a slug of liquid ammonia which could not discharge.

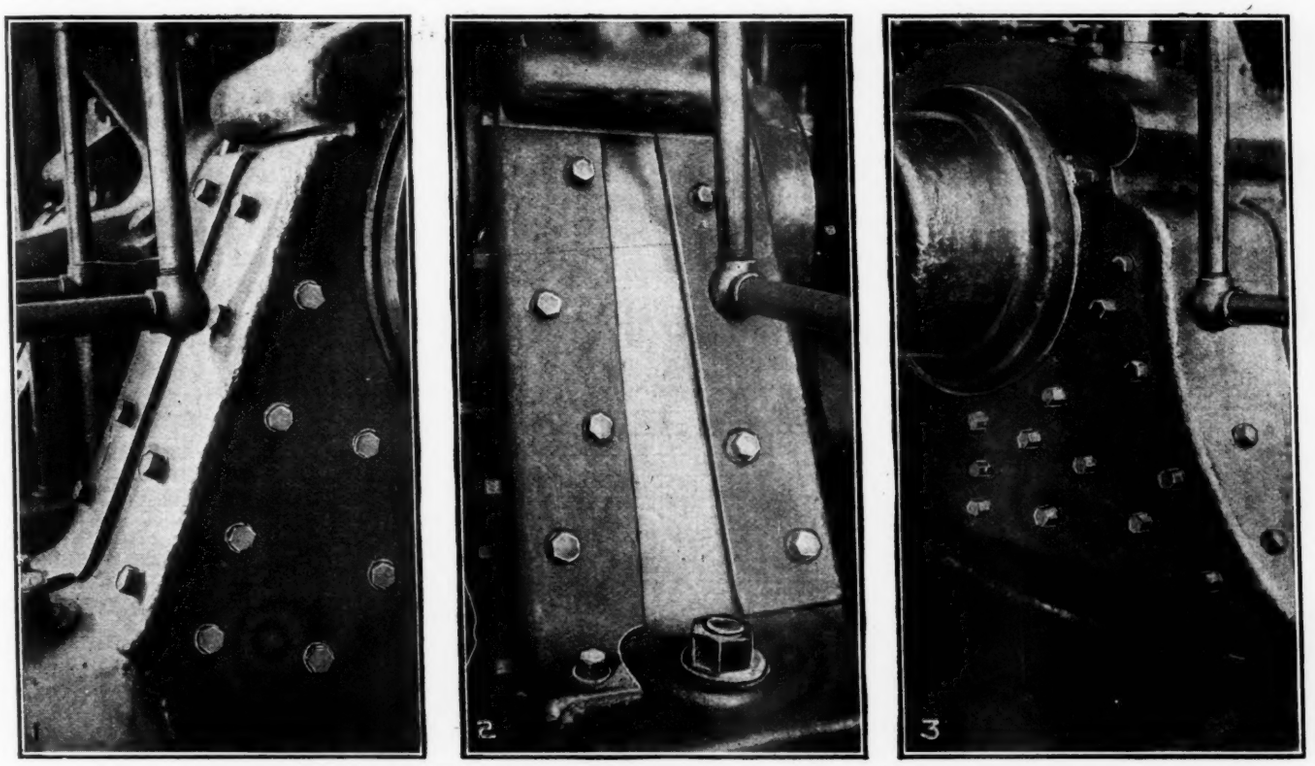
The shock was transmitted through the piston and connecting rod to the mainshaft, causing the main-bearing pedestal cap to break. This allowed all the pressure to go against the rear quarter-box, splitting the pedestal apart and cracking the cap and pedestal of the engine main-bearing through the misalignment of the mainshaft.

*Superintendent Lafayette Ice and Coal Co., Lafayette, Ind.

The discharge stop valve was now closed, and a connection was made to the sewer to allow the remaining gas to clear from the cylinder. The damaged bearing caps were removed for welding, and the mainshaft was jacked back into position. While waiting for the gas to clear from the ammonia cylinder, we secured some ¾-in. boiler plate and laid off four patches, two for each pedestal. Each patch was in two parts, which were to be laid up at right angles to each other so as to form a heavy angle along the side and front. The corners were then welded, making a one-piece patch. Holes were drilled for 1-in. capscrews. The plates were mounted on the pedestals and the capscrews inserted.

While this work was going on, the damaged valve was taken out, as was the opposite one. The spring was in three pieces, and the valve disk was broken from its stem and jammed tight in the seat. New valves were ordered, and while waiting for them, the piston was removed for inspection. The cylinder walls were found to be in good shape, and the piston rod upon being placed between lathe centers was found to be true as was also the connecting rod. The new valves arrived before the patching job was finished and were put in place. A new cap for the compressor pedestal was ordered for emergency use.

After the capscrews holding the patch plates were tightened with a three-foot wrench and quarter-boxes adjusted as near to the old setting as possible, the machine was started slowly, and as no trouble was encountered, it was gradually brought up to 80 r.p.m. The machine ran about a week when the welded cap on the compressor main bearing opened up along the old fracture. The new one being on hand, a quick change was made, and no further trouble was experienced during the remainder of the season. The entire job took a week to complete, and as there was no other machine at this plant, the ice cans had to be pulled and emptied.




FIGS. 1 TO 3—VIEWS OF BEARING PEDESTAL AFTER BEING REPAIRED

## Overcoming Unaflow Cylinder Trouble

An important item in connection with unaflow cylinder manufacture is that it is necessary, in view of the different temperatures between the middle and ends of the cylinders of these engines, to bore them slightly barrel shape, the center having the larger diameter, the difference being as much as ¼ in a 60-in. cylinder. The gradual temperature drop along the cylinder has been proved by experiment by taking readings close to the inside of the cylinder and cover surfaces, and results are as follows: Cover surface, 400 deg. F.; the cylinder surface halfway between cover and center exhaust ports, 250 deg., and at the center 160 deg. High superheat can generally be used quite safely in unaflow engines, as the mean temperature at any point on the barrel varies little.

Builders of unaflow engines employ a more or less orthodox type of piston, making it, of course, of suitable length and having ordinary ring packing. It must be remembered that the temperature changes necessitating a barrel cylinder bore also affect the piston diameter. It is easy to see that the piston will be hot at the ends and cooler about the center. Hence the piston also requires turning double taper, in order that it may be as nearly as possible a true parallel cylinder when at work. It is necessary to observe the rule—that under any or all circumstances, even the worst—that is, a hot piston in a cold cylinder—the piston must have clearance. The lower third of the piston must fit the bore of the cylinder, otherwise line contact only takes place, followed by wear and tear and risk of overheating.

The two difficulties are overcome in small engines by boring and turning during manufacture and by turning the piston or the shoe thereon in two operations. For large pistons, however, this is not considered wholly satisfactory. For example, in a 60-in. cylinder with 72-in. stroke the piston is about 66 in. long. Owing to changes of working load, changes in steam pressure and superheat temperature, it is certain that the bottom of the cylinder can never consistently be a dead true straight line, nor will the piston be straight. The result of these considerations led to the adoption of a piston shoe composed of a number of slippers flexibly supported and capable of independent radial movement, thus accommodating themselves to any minute difference of cylinder diameter consequent on variations of temperature. This fixes the bearing pressure per square inch at a predetermined amount. The piston is fitted with two rings placed close to the ends, to prevent steam getting on top of the piston and causing wear.

# Chart for Saving by Feed Heating

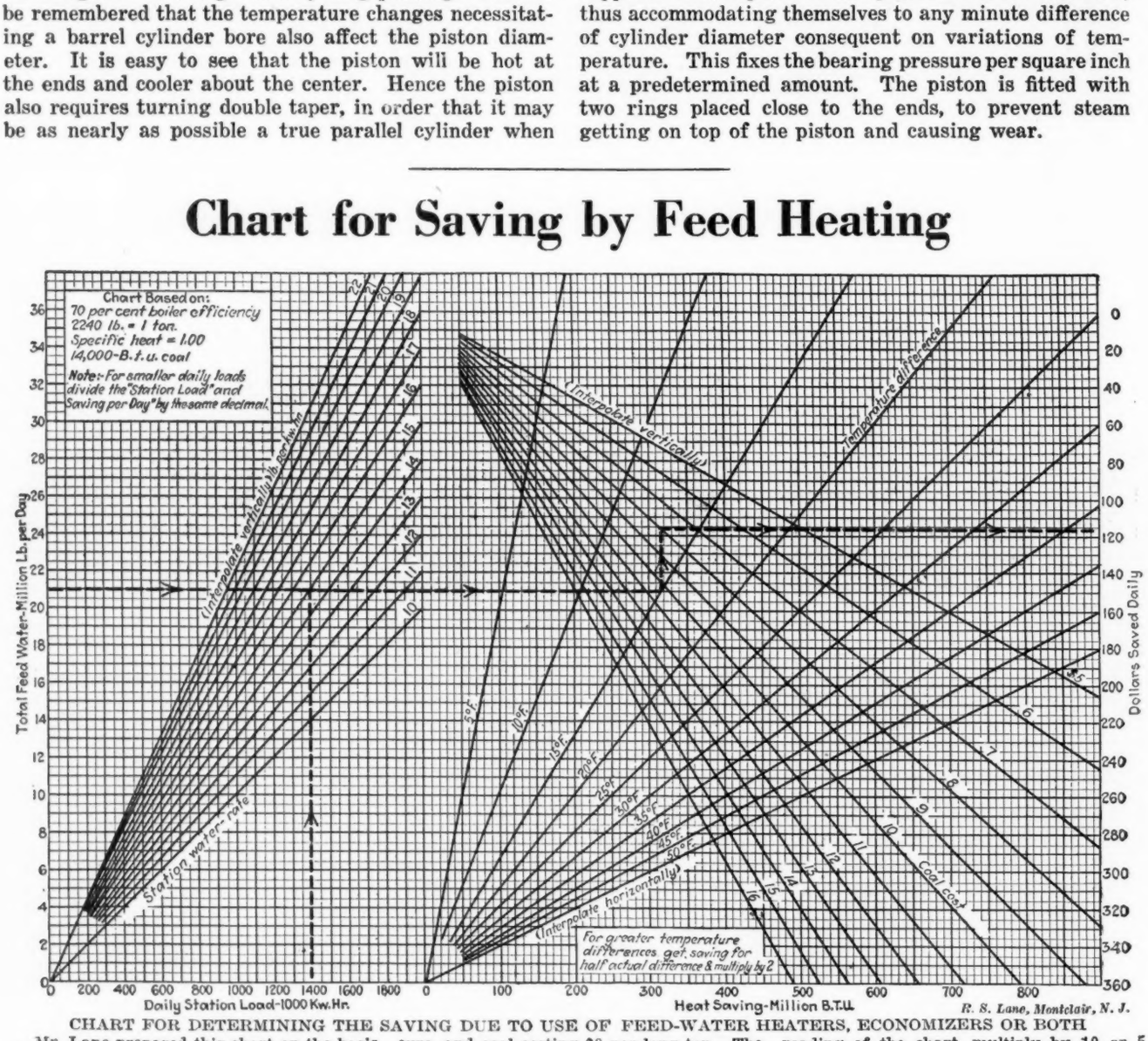


Chart Based on:
70 per cent boiler efficiency
2240 lb. = 1 ton.
Specific heat = 1.00
14,000-B.t.u. coal
Note:-For smaller daily loads divide the "Station Load" and Saving per Day" by the same decimal.
(Interpolate vertically)
Station water-rate
(Interpolate horizontally)
Temperature difference
Coal cost
For greater temperature differences get saving for half actual difference & multiply by 2
Total Feed Water-Million Lb. per Day
Dollars Saved Daily
Daily Station Load-1000 Kw.Hr.
Heat Saving-Million B.T.U.
R. S. Lane, Montclair, N. J.

CHART FOR DETERMINING THE SAVING DUE TO USE OF FEED-WATER HEATERS, ECONOMIZERS OR BOTH

Mr. Lane prepared this chart on the basis indicated in the upper left-hand corner. The dotted line illustrates the method of solution by working out the saving for a plant with a daily station load of 1,400,000 kw.-hr., an average water rate of 15 lb. per kw.-hr., a 15-deg. increase in feed temperature, and coal costing $8 per long ton. The answer obtained is a daily saving of $116. The solution could have been started with the total daily feed water, in this case 21,000,000 lb., as shown by the dotted line on the left. Where the daily load or total daily feed water is too low to permit close reading of the chart, multiply by 10 or 5 before entering the diagram, and divide the final answer by the same number. Where the price of coal is in dollars per short ton, multiply the answer obtained from the chart by 1.12. In the above problem this would make the daily saving 116 × 1.12 = $130.

# Seventeenth Century Waterwheels

At Marly on the Seine near Paris, Louis XIV had built by engineers, whose names are now forgotten, a most remarkable pumping plant to supply water for the fountains at Versailles. This installation was the forerunner of large-sized pumping equipment by means of water power. The construction was carried out between the years 1664 and 1685. The undershot waterwheels operated walking-beam type pumps whose tops are shown in the picture. The water was pumped to the aqueduct shown at the top of Fig. 2, a difference in level of 500 ft. This elevation was reached in three stages, the motive power for the upper stages being transmitted by rods. Pressures due to 500 ft. head could not be confined in the flanged cast-iron pipe of that day. From the aqueduct the water flowed by gravity to the fountain. Altogether about 200 pumps were used and 15 miles of pipe lines. The waterwheels were approximately 30 ft. in diameter and must have presented an especially difficult erecting job for that day.

The machine here shown was in use until about 1801, the time of Napoleon I, when it was replaced by a steam engine designed by James Watt. The steam-driven pumps in turn were replaced by hydraulic machinery now in use.

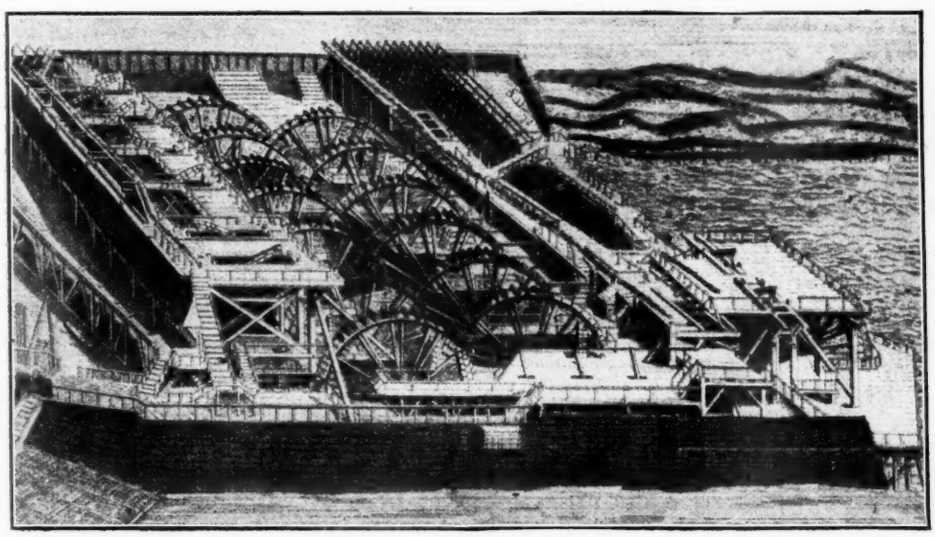


FIG. 1—THE UNDERSHOT WHEELS OPERATED WALKING BEAMS THAT IN TURN, WORKED THE PUMPS

The pipe founder has always been interested in the fact that the cast-iron flanged pipe used in this system is still in use and in good condition. It was cast in lengths of approximately a meter and the sections bolted together.

Many English books on hydraulics refer to the Marly installation, but few present illustrations. The colored woodcuts from which these halftones were reproduced by utilizing color screens, were picked up in a curio shop in Paris, by Paul M. La Bach, engineer, water service, Chicago, Rock Island & Pacific Railroad. Mr. La Bach was fortunate enough to see repairs on one of the 250-year-old pipe lines to one of the fountains. The pipe, which had been broken out, appeared to be of gray cast-iron in good condition.

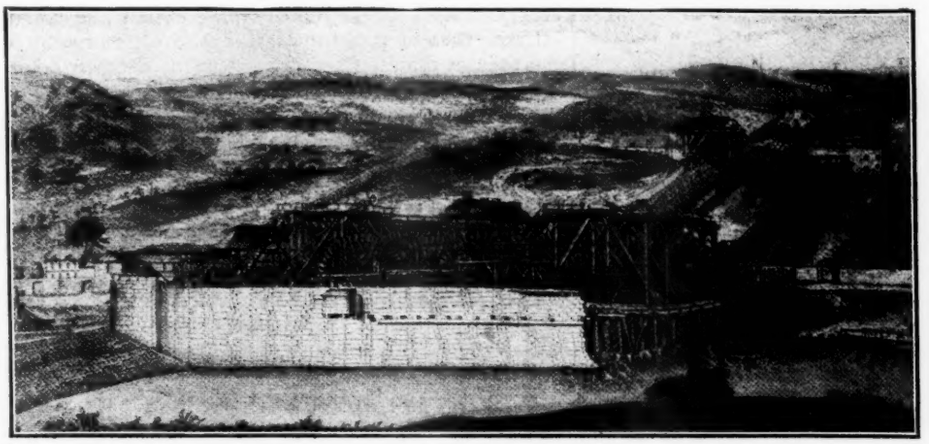


FIG. 2—GENERAL VIEW OF PUMPS AND AQUEDUCT

## Care of Steam Strainers for Turbines

Manufacturers usually supply or specify a strainer to prevent solid material from being carried into the turbine by the steam. On account of the trouble connected with inspecting and making up steamtight joints, etc., strainers for small machines seldom receive attention.

When neglected indefinitely, strainers may become filled with solid material to such a degree that the load-carrying capacity of the turbine is noticeably reduced. Pipe scale, gasket material, chips from repair work or welding on header or boilers, as well as sediment from the steam, are often encountered. Conditions may sometimes cause parts of a strainer to rust out, possibly resulting in damage to the turbine blading.

Inspection should be made at least once a year, in order to check the strainer condition. It is also advisable to see that the strainer is not put in "backward." A support for the screen is used in many types. This should be located on the turbine side of the screen and not on the header side. Clearance between the screen element and its container is very important. Warping or growing often takes place and produces a noticeable clearance, allowing solid particles to work their way through such joints.

"----- The Commission shall ascertain and report to the President and Congress: As to the ownership and titles of the mines; prices of coal; cost of production; profits realized by the operators or owners of said mines during the last ten years; profits of other persons or corporations having to do with production, distribution, or sale of coal; labor costs; wages paid; wage contracts; irregular production; waste of coal and suggestions as to the remedy; distribution; the causes which from time to time induce strikes, thereby interrupting the flow of interstate commerce; and all facts, circumstances, or conditions which would be deemed helpful in determining and establishing a wise and efficient policy by the Government relative to the coal industry."

—*From the Coal Commission Act*

# Too Many Mines and Miners, Says Coal Commission

"*THERE can be no permanent peace in the coal industry until conditions of overdevelopment in the mines and of a surplus of miners are removed. . . . There can be no agreement as to wage rates unless steadier employment is provided. There can be no solution of our transportation problem as long as the railways are subjected to sudden peak loads of coal traffic at the season when the demands of agriculture and industry are at their height, and no solution of our coal problem that does not recognize the community of interest between coal and transportation. . . . Much may be done to overcome irregular demand, to stabilize the industry and to reduce the price of coal to the consumer by encouraging the storage of coal.*"

Such are the outstanding conclusions of the President's Coal Commission as embodied in its preliminary report to Congress, the result of less than three months' work since the first meeting of the Commission on Oct. 18, 1922. In so short a time little more than a preliminary survey of the industry could be made.

The unsatisfactory service and high prices characteristic of the coal industry have been attributed by some to profiteering, by others to irregularity of demand, to labor troubles, to "car shortages" and to overdevelopment of the industry. The report treats of these factors as follows:

While it has been suggested that one of the prime causes of high prices is profiteering, the Commission has not yet obtained the figures for the last ten-year period, specifically required by the act in order to settle this question.

Another evil is the variation in demand—greater in winter than in summer. The Commission believes that loss of time in summer is unavoidable unless some means may be found to encourage the storage of coal during the dull months, which would tend to even up distribution and cost, distribute employment in the mines more evenly throughout the year and benefit the railroads by equalizing their load.

With regard to the third factor—labor troubles—the Commission reports that there can be no doubt that two of the three periods of high prices since 1916 have been largely caused by labor troubles. However, in the first period of scarcity—August, 1916, to March, 1918—there were no strikes of consequence, therefore some other explanation must be found.

Upon still another evil—transportation deficiency—many would place the entire blame. However, while there have been recurring periods of "car shortage," accompanied by high prices of coal, the so-called car shortage is due not so much to insufficient coal-carrying equipment as to the overload that invariably falls upon the railroads after a period of idleness at the mines.

Although lack of transportation facilities increases the cost of coal to the consumer, it does not explain the short working year for the miners. This, the report states, is the result of *overdevelopment in the industry*, which the Commission places above all other factors as the real cause of the trouble. Even in times of maximum demand the mines as a whole do not work full time. Although the country has never needed more than 579,000,000 tons of bituminous coal a year, the present capacity of the mines is well above 800,000,000 tons. There has also been a steady increase in the army of bituminous coal miners during the last four years.

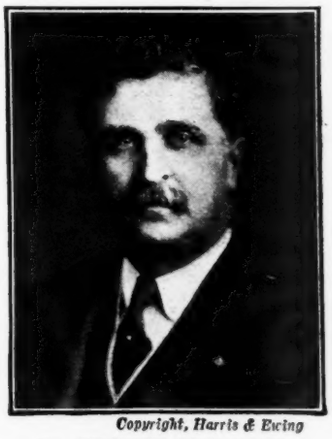
Owing to the short time since it began to function, the Commission has been unable to formulate any recommendations as to the exact methods of reducing overdevelopment in the coal-mining industry. Nor is it able to report on wage scales, on costs and profits, or on the great wholesale and retail problem.

In closing, the report raises this pertinent query: "*What is best for the people—free competition, government or private ownership, regulation or control in the coal industry?*

"Should the operators in given areas be permitted to combine so that the low-cost mines would furnish the product to the people and the high-cost mines kept in abeyance to meet an emergency, properly regulated as to price and profit by some governmental agency, or should this prime necessity of life and business be left wholly to open competition in the market? This problem is of so great moment, with reference not only to theories of government, but also to the economic life of the Republic, that the view of the Commission must be left to its final report.

"*IT MAY BE that both private property in an exhaustible resource and labor in a public-service industry must submit to certain modifications of their private rights, receiving in return certain guarantees and privileges not accorded to purely private business or persons in private employ.*"

# The United States Coal Commission



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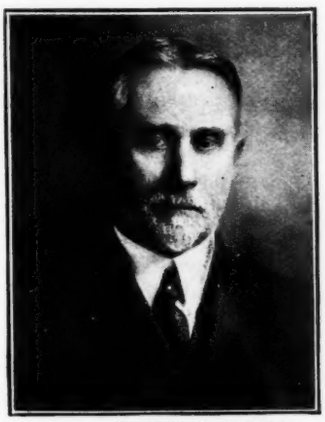
DR. GEORGE OTIS SMITH

Engineer, authority on coal and for more than fifteen years director of the United States Geological Survey.



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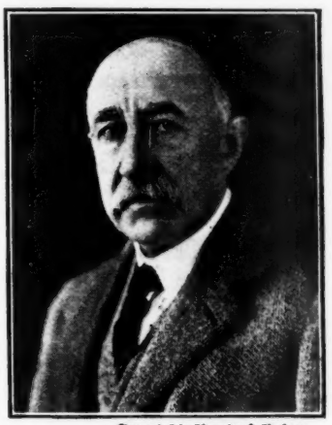
CHARLES P. NEILL

Prominent authority on labor problems. Served on Roosevelt's anthracite commission. Has successfully settled many labor disputes.



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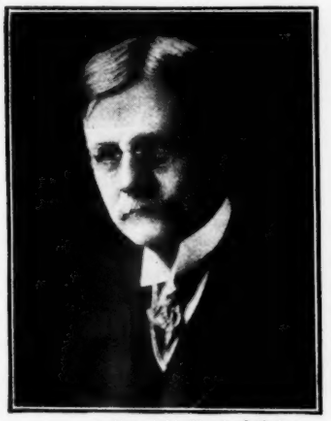
JOHN HAYS HAMMOND

Chairman. Mining and financial expert, one of a group of remarkable Californians that has injected science and specialization into mining.



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THOMAS R. MARSHALL

Attorney, vice-president during the Wilson administration and a keen observer of economic and social conditions.

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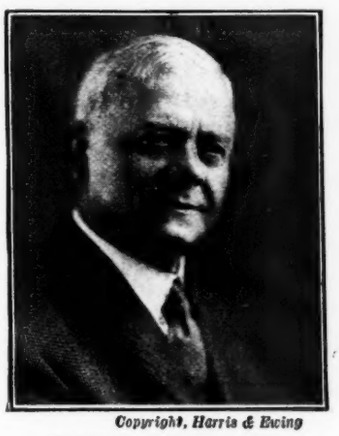
DR. EDWARD T. DEVINE

Widely known as a writer and lecturer on social and economic questions. Formerly edited the *Survey*.



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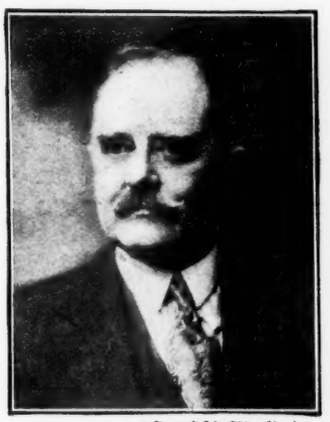
SAMUEL ALSCHULER

Circuit Court judge and labor arbitrator. Handled dispute in 1918 between Chicago packers and their employees.



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CLARK HOWELL

Editor of *Atlanta Constitution*. Served in Georgia Legislature. For many years Democratic national committeeman for Georgia.

FIG. 1—VIEW OF BOILER SHELL AFTER EXPLOSION, 300 FT. FROM ORIGINAL LOCATION

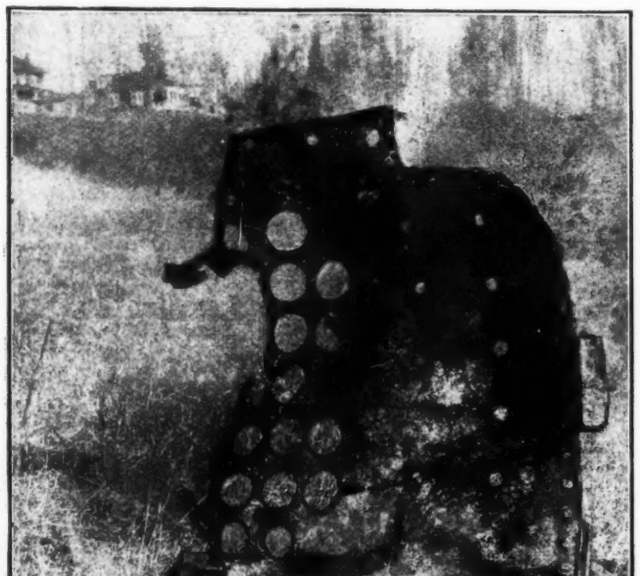

FIG. 2—VIEW OF TUBE SHEET, FIREBOX END, BLOWN ABOUT 250 YD. FARTHER THAN BOILER

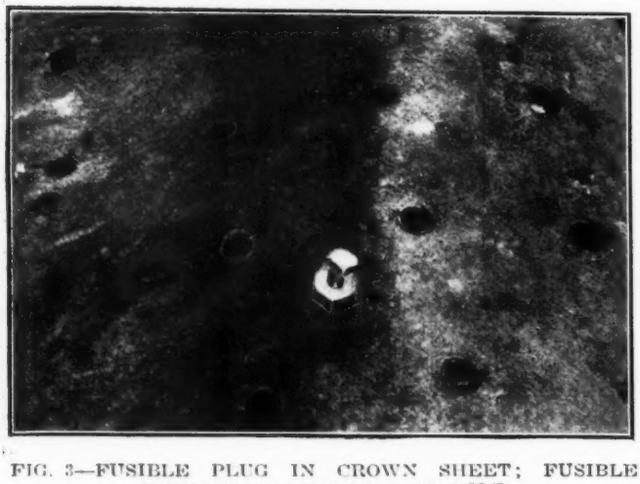

FIG. 3—FUSIBLE PLUG IN CROWN SHEET; FUSIBLE METAL REPLACED BY ¾ IN. BOLT

# Low Water and Removal of Fusible Plug Cause Boiler Explosion

At 4 p. m. on Dec. 27, 1922, a small boiler of the locomotive type exploded in a sawmill at Edge Hill, Pa., instantly killing the engineer and seriously injuring three other men, one of whom has since died. An investigation made shortly after the explosion revealed the following details:

The boiler was of the portable type, with a small engine mounted on a saddle on the top of the boiler shell. The shell was 36 in. in diameter and 11 ft. 10 in. long over all and was constructed of ¼-in. plate with a double-riveted lap joint. The pitch of the rivets in the longitudinal joint was 3¼ in., and the efficiency of the joint was approximately 72.8 per cent. The tube sheet was ⅜-in. plate and was fitted with twenty-eight 3-in. tubes. The estimated age of the boiler was about 12 years.

The shell, shown in Fig. 1, was blown about 100 ft. into the air, and fell in a lot about 300 ft. from its original location, part of the tube sheet, Fig. 2, being found about 250 yards farther out in a direct line with the path taken by the boiler, while the crown sheet was found about 100 ft. from the original location of the boiler and in an opposite direction from that taken by the boiler itself.

The crown sheet was noticed to be badly burned and the fusible plug was found in its proper position, but the fusible metal was missing and a ¾-in. bolt substituted. No information could be obtained as to what pressure was carried or allowed on the boiler. The owner and operator of the mill, upon being interrogated in the matter, stated that he did not know anything about the boiler, leaving all matters of this kind in the hands of the engineer, who, he presumed, was competent to take care of such things. However, the results of this investigation clearly prove that such was not the case. In the first place the owner stated that the boiler was not insured nor had it ever been inspected by an authorized inspector since coming into his possession; secondly, the condition of the fusible plug shows evidence of utter negligence or ignorance, and a competent engineer would under no circumstances allow such a condition to exist. He would have realized the danger of operating a boiler in this condition, and would have corrected it at the earliest opportunity.

The 2-in. lever safety valve was found among the débris and was in good working condition and showed evidence of having been weighted to blow at 80 lb. There is no doubt at all, from the condition of the tubes which are collapsed and the condition of the crown sheet, that the disaster was caused by low water. This decision is further substantiated by testimony from witnesses who state that the "engineer" was making an attempt to start the injector and the owner's son, who was also employed at the plant, made an effort to stop him but was unsuccessful. A few minutes later the boiler exploded.

Undoubtedly, had the boiler received periodical inspection by an authorized inspector, the condition of the fusible plug would have been detected and it would have been ordered replaced by a new plug and this undoubtedly would have prevented this particular accident, with its loss of human life and property damage.

# EDITORIALS

F. R. LOW, EDITOR

## The Coal Commission's Preliminary Report

THE Commission appointed under an act of Congress, approved September 22 of last year, "to investigate and ascertain fully the facts and conditions and study the problems and questions relative to the coal industry" has, in accordance with the requirement of that act, that its first report shall be rendered not later than January 15, submitted the document abstracted elsewhere in this issue.

This report presents rather an analysis of conditions, painted with a broad brush, than the finding of previously unrecognized facts, with the explanation that "queries could not be prepared, submitted and answered and the returns analyzed or the field work completed within this short period of time allotted. An extensive organization has, however, been completed and a study made of the undisputed underlying facts to be learned from the reports of previous investigations and from the activities of such Federal agencies as the Geological Survey, the Bureau of Mines, Bureau of the Census and the Federal Trade Commission, preparatory to a searching inquiry for new material under its powers of subpoena and examination.

However, the report does express the appreciation by its signers that the act creating the Commission is an expression of a feeling of public concern and dissatisfaction, and several passages in it are indicative that its members are approaching their task in a spirit that promises some freedom in their viewpoint and possible recommendations from that over-concern for established claims and practices that has resulted in the present unsystematic and inefficient exploitation of this basic natural resource. Quoting from the report:

> With resources of coal in the ground, adequate for the needs of perhaps a hundred generations of Americans, the nation's coal bin is too often depleted and too often the prices paid for coal are much higher than seem warranted by the wealth of coal available.
>
> Every industry and every citizen throughout the country is directly or indirectly dependent upon coal.
>
> Combined charges of the railroad, the wholesaler and the retailer in most localities exceed the price of the coal at the mines. Therefore, it is readily seen that the problem whether the transportation and marketing charges are just and fair is of the utmost concern to the consumers of coal.

A searching investigation into the processes by which the items of cost were transferred from the mine when public attention was focused in that direction to the less obvious processes of transportation and marketing, and as to what extent the "unconscionable profits," if such there are, find their way into the same pockets, will be an interesting phase of the situation for the Commission's attention.

> There has been profiteering in the sense that grossly exorbitant profits have been taken at times by many operators, brokers and retailers; profits that have been disproportionate to the cost of the coal or the service rendered or the risk incurred.
>
> A thorough examination of the profits of production and distribution, including the revenue derived from associated enterprises, is already under way.

This is reassuring, and it is to be hoped that the results, whatever they turn out to be, may be made fully accessible to the public. More than that, that they be given the fullest publicity. The American people are willing to pay the full cost and a fair profit upon any service rendered to them, and nothing will do more to dispel their dissatisfaction and to correct abuses, if they exist, than the fullest exposure of all facts.

> Whatever the cause or the merits of the labor controversy, it is clear that an indefinite repetition of these crises in the production and distribution of coal would be intolerable. Industry and the home alike must be freed from the menace of constant interruption of their coal supply.

This may be received by a victimized public as an assurance that the Commission is not blind to the common purpose of the miners and operators to get more money out of the public and of a possible entente for that purpose.

To the laborer in the mines the American people are also fully as anxious to make adequate, generous payment for his services, and it is to be hoped that the revelations of this study may afford a means for the settlement of the terms of such requitement without further attack by organized labor upon the stability of industry and the comfort, health and convenience of the whole people.

A gleam of hope as to the possibility of some far-reaching fundamental and permanent readjustment of basic conditions, without which any expedient will be of but temporary effect, is contained in the concluding paragraph of the report.

> It may be that both private property in an exhaustible resource and labor in a public-service industry must submit to certain modifications of their private rights, receiving in return certain guarantees and privileges not accorded to purely private business or persons in private employ.

## Convincing the Management that More Reserve Equipment Is Necessary

THE man in charge of a power plant may be able to secure reserve equipment as he desires, but if so, he is an exception. Occasionally, the management is broad-minded enough to listen patiently and make some constructive effort to assist the engineer; if the latter is able to put forward his case in a convincing manner, he is in a fortunate position and needs no advice or sympathy. The average engineer feels that improvement in power generation is not interesting to the management or else finds it beyond his power to put forward his case successfully. Such a state of affairs is usually considered as an evil that necessarily goes with the job and must be accepted with philosophic humor—resistance is often a waste of energy. In many cases the burden can be made lighter by a little effort along definite lines; whether this is successful or not, there

remains the consolation of having taken some constructive action, which is frequently the only comfort possible.

There are a number of ways in which such a situation may be handled. In the first place one feels the discouraging side and thinks, "Let trouble take its course; the loss of a few dollars will soon force an appropriation." Fortunately, few chiefs really have the heart to let things reach such a climax. A personal reputation is often at stake, perhaps a job, so he usually "pitches in" and works nights, holidays and Sundays in order to keep things going.

In keeping the plant operating, the engineer is in a way working against his best interests. Satisfactory operation may nullify his arguments for an expenditure. Furthermore, excessive physical and mental strain renders a man less able to attend to ordinary duties, supply difficult explanations or make the proper decision where the best judgment is required. In many cases it seems like working in a groove too steep to be climbed.

A fresh, brand-new point of view may be of assistance. The engineer's strength lies largely in his knowledge. When he is absolutely sure that additional equipment is positively needed, not as a convenience but as a reasonable investment to secure continuity of service and reliability, he must inform the management to this effect, which, needless to say, he probably has already done until sick of making requests. The next step is to devise a system for keeping the responsible parties informed of the plant condition. Arrange for weekly or monthly reports to reach directly those concerned in providing equipment; this may be easy or practically impossible, depending on the political aspects of the situation and the chief's ability to enlist his superior's assistance. Predict difficulties when such a course is strictly advisable, bearing in mind that the engineer must make allowances so his information will be worth relying on. He should keep his own efforts well in the foreground.

Now if disaster arrives and the chief has done his duty, there is no "come-back"; his position is fixed in advance; should business improve and a little spending be advisable, and the power plant is known to be in difficulty—it will be easier to secure consideration for it. If circumstances are such that no improvement can be forthcoming, such as might be expected where a small plant is to be superseded by other sources of power, the chief has demonstrated his ability and would not be justified in wasting it where no reward is in sight.

## Here Is Another

IF ENERGY, transmitted electrically or in some similar form, could economically be made generally available for all our power, heating and lighting needs, it would revolutionize human existence. The possibilities of doing this have attracted the attention of a great many men—some honest, others out-and-out impostors. Cheap fuels, utilization of the inexhaustible supply of energy in the atmosphere and perpetual motion are some of the standards that the latter class have sailed under. Many *Power* readers will recall T. K. Giragossian, who a few years ago tried to exploit his so-called "Garabed" method of making use of the inexhaustible supply of energy that exists everywhere and so impressed Congress as to secure special legislation in his behalf. An investigation made by a committee of five engineers and scientists approved by the Secretary of the Interior showed Mr. Giragossian to possess nothing to substantiate his extravagant promises, and he has now passed into the category of perpetual-motion cranks and power-generating fakirs.

Another of these would-be geniuses was Louis Enricht, of Farmingdale, L. I., with his "cent-a-gallon gasoline," who, failing to demonstrate his claims in court, has had to travel the road that many others of his class should. Before reaching the end of his exploitations, he succeeded in attracting international attention to his supposed process of sprinkling a green powder into water to produce a fuel similar to gasoline.

There is apparently another heading our way, a Russian, Makhonine, who claims to have developed an electric train that weighs one hundred twenty tons and runs four hundred miles without a stop on thirteen pounds of naphtha. According to reports, one day, after hauling Mr. Dzerjinsky, the great master of the Tcheka, from Petrograd to Moscow, Makhonine obtained permission to leave Russia. He is now in Paris and, according to Stephane Lauzanne, editor of *Le Matin*, is offering to the French railroads the secret he would not give to his own government. The reports have it that once the inventor left Russia, it became impossible to move the wonderful train. He says that his engine produces its electrical energy itself, thanks to the use of naphtha in a special apparatus placed in the engine, but this does not account for hauling a one hundred and twenty-ton train four hundred miles on thirteen pounds of naphtha or gasoline.

Although there is nothing concrete available to form definite conclusions on, the supposed inventor's methods savor of many of the mysterious schemes that had appeared and disappeared before Makhonine claimed to have made his discovery. Even if he built and operated a train in Russia, as claimed, this is not proof that he has discovered anything. Keeley demonstrated to the layman that he ran his motor on supposed vibratory energy, Louis Enricht his automobile on a tankful of water and a little green powder sprinkled into it from a bottle he carried in his vest pocket. Looking back over the records of mystery men, there is little to mark their achievement but a list of unsavory episodes.

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The latest coal dope is "Victory Coal Save," a powder which "in a moment's time" is dissolved in hot water and sprinkled over the coal. "It is a wonderful combination of chemicals which, at a certain heat, produce oxygen." It is guaranteed to save 25 per cent of the coal used, and put up in two sizes, 97c. and $1.90 per package. We have no sample, but know that there is no chemical or combination of chemicals that will do what the advertisement claims, and caution our readers against tampering with it without the most complete and convincing demonstration.

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Once more an engineer has replaced the fusible plug with a bolt at tremendous cost; and inspectors still ocasionally find props between safety valves and sidewalks in our metropolitan districts.

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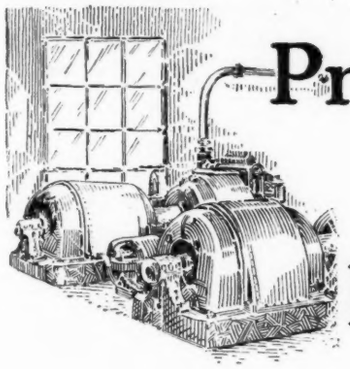
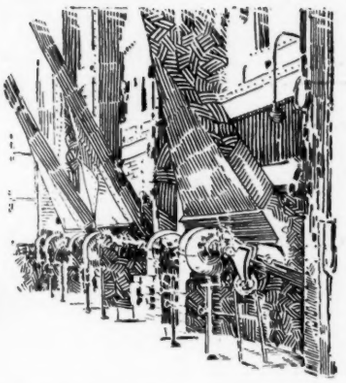
The index for the second half of 1922 is now ready and will be furnished free upon request. Furthermore, subscribers wishing to receive the *Power* index regularly every six months should so indicate, and their names will be placed upon the index list.



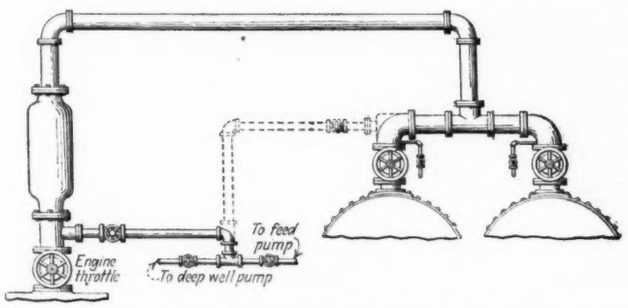
# Practical Ideas *from* Practical Men



## Inadequate Steam Piping

The main equipment of a small factory power plant comprises a pair of horizontal return-tubular boilers and a high-speed engine. The principal auxiliaries consist of a direct-acting steam pump for boiler feeding and a steam-driven deep-well pump to supply water for manufacturing purposes.

When the plant was installed, the steam piping was arranged as shown in the cut, the branch for the pumps




SHOWS CHANGE MADE IN STEAM LINE TO PUMPS

being connected directly beneath the separator in the steam line to the engine. This arrangement worked well at first, because the engine was lightly loaded, but trouble ensued when the load on the engine was increased. The engineer then found that he could not get enough steam through the branch to run the pumps at the proper speed. Changing the branch line, as indicated by the dotted lines in the sketch, corrected the difficulty.

A. J. DIXON.

St. Louis, Mo.

## Pertinent Queries on Power-Plant Design

Much has been written concerning the installation and erection of new equipment without the co-operation or advice of the operating engineer. This is not as it should be. The plant designer cannot be expected to know all the small operating details or the defects in construction of all the apparatus he wishes to install. Innumerable instances can be cited where equipment is given preference and purchased on the basis of a 1 or 2 per cent gain in economy which it is impossible to maintain and on which the maintenance is excessive.

High pressures and temperatures call for the greatest simplicity in plant construction, and a few questions might be asked as to why certain things are done. To illustrate, why cannot the majority of butt-strap seams in boilers be placed as far as possible in such a position that they can be calked and repaired without its being necessary to tear down boiler walls and work in inaccessible places?

Why so much fuss about steam nozzles on high-pressure boilers? If these nozzles are to be welded to the drums, as it has been necessary to do in a great many cases, let us do it in the shop.

Why not make the seats of non-return valves that are built for 300 lb. pressure rigid enough so they will hold tight both ways? There are some valves that are tight against back flow but not so when closed against the pressure.

Why are the majority of small steam turbines, used to drive auxiliary apparatus with 620-deg. steam, not designed with more liberal bearing cooling devices? The exhaust temperature in these turbines is usually from 300 to 325 deg., and the bearings and bearing bracket lengths are the same as used with 212-deg. steam.

Why do the makers of small auxiliary apparatus like turbines, reduction gears and pumps talk so wonderfully about their product and then spoil it all by the poor piping work used in connection with the oiling and cooling systems? If it is necessary to use oil coolers, separators or filters in connection with consistent turbine operation, why not include these items in the turbine contract, so that the cooling or filtering system will be a part of the unit? This apparatus can be purchased and installed much easier and more symmetrically at the time the main unit is erected. Too many sales engineers make the statement that their apparatus will operate without this additional expense, with the result that the management considers their installation unnecessary, all of which later reflects on the unit installed.

In the design of modern industrial installations, careful attention is given to the different processes of production to see that no time is lost between processes. How many electrical plants are designed along that line? It is well known that it is impossible to avoid certain arrangements of apparatus, but in general not enough attention is given to confining so far as possible the individual duties of the operating force to one floor. In the installation of coal- and ash-handling machinery the tendency in the past has been to place this vital part of the plant equipment in small, poorly ventilated and lighted tunnels or out of the way places, or to provide several types of conveyor, motors, etc., all mechanically interlinked but electrically separate. In the case of one link failing to function, the other parts continue to operate, piling up coal or ashes until the trouble is discovered or the whole system is down.

Why install economizers and erect the building over them and then discover there is not sufficient room, supports or openings to enable replacements.

Denver, Colo. F. W. LAAS.

# Method of Reducing and Recording Consumption of Steam-Jet Ash Conveyor

In power plants that operate condensing, the amount of makeup water required per day to make good the losses is in most cases measured and a record kept of it, along with the general daily report. Where the condition of the water is such that treatment is necessary before it is fed to the boilers, a careful check is usually kept on the amount of water required. In plants where a steam-jet ash conveyor is installed, the amount of makeup water is increased considerably and provision is usually made to measure the amount of steam supplied to the conveyor so that a check may be kept on the other losses.

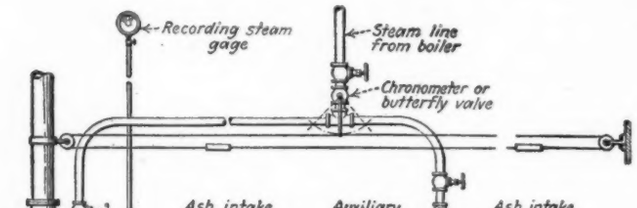



FIG. 1—SHUTOFF VALVE IS OPERATED BY ENDLESS CABLE FROM ANY POINT ALONG CONVEYOR

To keep the steam consumption of the conveyor at a minimum, it is essential that the maximum amount of ashes be continuously fed to the conveyor during the time steam is on the main jet. This, however, is seldom followed up in practice, and considerable steam is wasted by allowing the conveyor to run empty during such times as changing from one ashpit to another, opening and closing ashpit doors, etc.

The illustration shows a typical installation of this type of conveyor and one method of reducing the steam consumption by installing a chronometer or butterfly valve in the steam line from the boiler. This valve is operated by an endless cable running parallel with the conveyor and within easy reach of the operator, so that he can conveniently shut off the steam for short intervals from any point along the conveyor pipe.

By installing the valve in the steam line from the boiler, as shown in the cut, the main and auxiliary jets are controlled by one valve. Of course the arrangement of the steam piping and the method of operating the valve will depend upon the local conditions and it is optional.

Undoubtedly, the best method of measuring the amount of steam supplied to the conveyor would be by a steam-flow meter, but as the conveyor is used only a few hours a day, the installation of a meter in most cases is not warranted. Another means of obtaining a fair approximation of the amount of steam used is to connect a recording steam gage close to the main jet. From the chart the length of time that the conveyor is operated can be estimated, and the amount of steam used can be figured by using a formula for the flow of steam through a nozzle.

In Fig. 2 is shown a reproduction of a chart obtained from a gage used for this purpose, with a steam pressure at the nozzle of 175 lb. From the chart the length of time that the steam was on the main jet is readily found, which in this case equals 165 minutes, or $2\frac{3}{4}$ hours.

Using Napier's formula to obtain the flow of steam through a nozzle, the consumption of the main jet, $\frac{9}{16}$ in. in diameter and at 175 lb. pressure (no superheat), is found to be approximately 2,400 lb. an hour, and 2,400 × 2.75 = 6,600 lb. total consumption. Now assuming the auxiliary jet to have two $\frac{5}{16}$-in. nozzles, the consumption is found to be approximately 720 × 2 = 1,440 lb. an hour. The consumption then for this nozzle for 40 min., as noted on the chart, would be 1,440 × 0.66 = 950 lb. The total steam used by the conveyor then would be 6,600 + 950 = 7,550. Now to determine the pounds of steam per ton of refuse removed in a plant using, say, 70 tons of coal a day with an ash content of the 15 per cent, the weight of ash would be (disregarding combustible) 70 × 0.15 = 10.5 tons. Now if the refuse contained 25 per cent combustible, the total weight to be removed would be 10.5 + (10.5 × 0.25) = 13 tons. The pounds of steam per ton of refuse would then be $\frac{7,550}{13}$ = 580. From this figure the cost per ton of removing the ashes can readily be determined.

In plants where two or more boilers are in operation, the computation made from the chart can be checked up by isolating one boiler and using it only to supply the conveyor, if the steam pipe connections are suitable, and it is possible to weigh the water feed to the boiler.

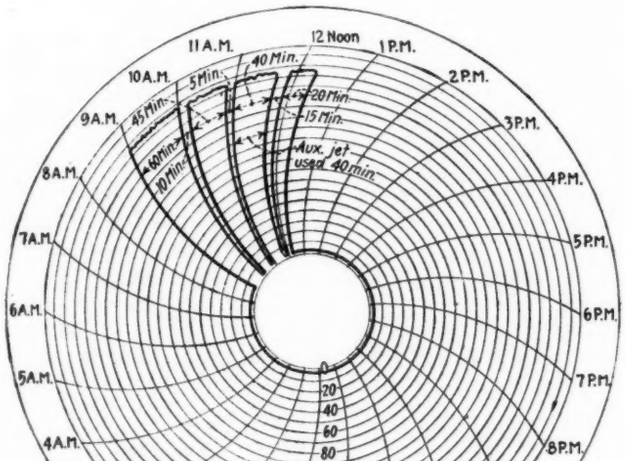



FIG. 2—RECORDING CHART SHOWING TIME THE CONVEYOR WAS OPERATING

It is essential that the steam pressure be kept uniform and the operation of the conveyor be as nearly normal as possible while making the test.

In the operation of these conveyors the jets should be examined from time to time, and if any appreciable wear has taken place they should be renewed, otherwise a considerable increase in steam consumption will result.

E. A. CURTIS.

Cleveland, Ohio.

# Comments from Readers

## Public Interest in Combustion

The comment by A. P. Hyde in the Dec. 5, 1922, issue brings to mind a flood of memories on the coal situations of the last twenty years. I was trained under an engineer who was an optimist, and in speaking of a standard price for coal, he used to say, "If a man pays less than I do for coal, he pays more."

It was some years before I could get either rhyme or reason to that adage, but when I came to the place where I assumed responsibility for the purchase of coal, I found its true meaning. The best coal that you can buy that is adapted to your furnace conditions, is the cheapest.

During the strike there was a general cleaning up of old coal around all mining districts, with the result that the coal which is being received today is fresh coal, minus a large accumulation of brickbats, etc., which seemed to make up an occasional car of coal before the strike.

Today in Minnesota we are receiving a 6x3[1] coal of much better quality than anything we have had for the last five years.

It is true we are paying $2 a ton more for it, but we are using less, have less clinker and ash to handle, and at the end of the year will have profited by the changed conditions.

I believe that the engineer who is getting a coal that is "going down in size and quality" is trying to buy coal for less than he should expect to under our changed National conditions. It is true "that the price of coal has nearly trebled since 1904," but there are few engineers today working for $80 a month, or laborers working for $1.25 a day, as they were in 1904.

Rochester, Minn. L. C. TROW,
Supervising Engineer Mayo Clinic.

## Unappreciated

Your article, "Interest and Application," in the Nov. 21, 1922, issue of *Power* has aroused my interest. Is your friend a man who is willing to observe and induce the spirit he wishes in his employees?

Certainly he is right! There are too many plant owners and managers who do not care how their help get along, they are too cold-blooded to consider them anything but a part of the machinery. Too many owners try to run on a shoestring, so to speak. Most of us—I refer to engineers and firemen—have served in plants where there was no possible chance to improve, owing to the scarcity of things to do with and the time to do it.

I have been striving to find such a man as you cite in your article. I am not a licensed engineer as yet, though I have held some important positions, both as an engineer, operator and erecting, where I have met with a certain degree of success, considering the fact that the installations have been giving excellent satisfaction.

I have not had the good fortune to acquire a steady position where my energy could be used to the greatest possible advantage. I have had to dig for every job I have had and have even been discharged by chief engineers because I made suggestions to those above them, so you see there are many drawbacks that you have no doubt overlooked.

It has been my habit since childhood (the teaching of my father) to work for the interest of my employer, but I have yet to see the employer that has had the opportunity or taken it, to observe my efforts. Perhaps I have not found the right one. I have seen too much jealousy in the men above.

[We suppress the signature and address of the writer for obvious reasons. If anybody in the West wants to give a chance to a man who is willing to put the best that there is in him into a job, we shall be glad to serve as the medium of communication.—EDITOR.]

## Horsepower per Ton of Refrigeration

P. Wilson Evans, in his discussion on Ammonia Condenser Reports, which appeared in *Power*, Jan. 2, gives a chart purporting to show the theoretical horsepower per ton of refrigeration. It is impossible to determine upon what basis this chart was prepared, for the values obtained from it are incorrect in all cases I have examined.

As example assume the back or suction pressure to be 24 lb. absolute, or 9.3 lb. gage, and the head pressure to be 260 lb. absolute (245.3 lb. gage). Mr. Evans' chart gives the horsepower per ton under these conditions as 1.7.

To check his value, turn to the ammonia heat diagram published in *Power*, Sept. 26, 1922, which is based on the charts issued by the Bureau of Standards and which are concededly accurate and differ only a slight degree from Goodenough's values used by Mr. Evans. At 260 lb. absolute the liquid ammonia leaving the condenser to pass into the coils, contains the heat of the liquid at this pressure and corresponding temperature. This is found to be 171 B.t.u. After evaporating at 24 lb. absolute, the ammonia will contain the total heat of saturated ammonia at 24 lb. pressure, or 608 B.t.u. The difference, 608 — 171 = 437 B.t.u., has been taken up in the coils. This is the cooling effect per pound of ammonia. In compressing this vapor heat is added, and on leaving the compressor at 260 lb. the superheated gas contains 770 B.t.u. The compression has added 770 — 608 = 162 B.t.u. Then to compress gas doing 437 B.t.u. of refrigeration, 162 B.t.u. of work is done; to do 200 B.t.u. of regrigeration, 74 B.t.u. of work is required. Since 1 hp. per minute equals 42.42 B.t.u., it is obvious that the horsepower per ton is $\frac{74}{42.42} = 1.4$. Mr. Evans gives a value of 1.7 hp. Other pressure values prove that the curves are entirely erroneous.

JOHN CASSIDAY.
Jersey City, N. J.

[1] Coal that passes through a 6-in. screen and stops on a 3-in. screen.

## Behavior of A.C. Generator When Field Circuit Is Opened

I was much interested in the article in the Nov. 14, 1922, issue on the behavior of generators when the field circuit is opened, as I have had some experience in that line. The prime movers in our station consist of one 100-kw. three-phase 60-cycle generator connected to two waterwheels through a belt and bevel gears, and two 300-kw. steam turbo-generator units. The belted generator is operated in parallel with either of the steam-driven units and with a fixed gate opening on the waterwheels, using all the water power available and letting the steam unit do the governing and carry the remainder of the load, which ranges from 150 to 300 kw.

One day I noticed by the instruments on the switchboard, that the steam unit was carrying all the load and the belted generator none. Upon investigating, I found that the brushes on one of the collector rings of the belted generator had stuck, leaving the brush clear of the ring and thus opening the field circuit. I loosened the brush and without any other adjustment the belted generator took its usual load, which was about 50 kw., the load going off the steam unit an equal amount.

Now it is my opinion that in this case the generator was not motorized, as the waterwheels were delivering the same power to the generator. There was no apparent change in speed on either unit, and they stayed in parallel. Both generators are equipped with automatic oil switches, but these did not open.

Owego, N. Y. G. C. NEWELL.

## Grain Size in Condenser Tubes

In the article, "A Year of Progress in the Power-Plant Field," which appeared in the Jan. 2 issue of *Power*, I notice, under the heading "Condensers," the following statement: "Attention has been drawn to the necessity of small uniform grain in condenser tubes as being conducive to longer usage."

I should be interested to know where the writer of this article gathered his information on small grain size being a necessity in condenser tubing. For some years the research department and laboratories with which the writer is connected have been experimenting and studying the question of fine grain size and its resistance to corrosion, and it is our opinion from all we have been able to learn that it is greatly debatable whether an extremely fine grain size adds anything to the service and long life of a condenser tube.

There is no accelerated test for corrosion, and condenser conditions vary so widely that it has been practically impossible to conduct any tests that would prove definitely such a theory. We have been told of many cases in which fine-grain tubes have failed where coarser-grain tubes have lasted in the same condenser.

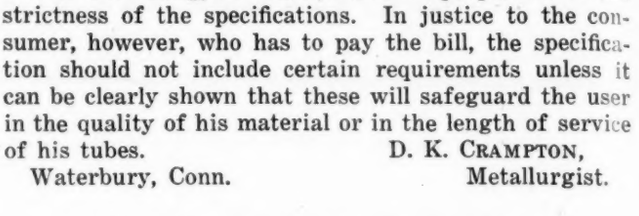
It should be remembered that grain size is but an approximate measure of metal temper. This condenser-tube temper should fall between certain limits as outlined in most modern specifications, but there is a real objection to too fine a grain size in that in order to produce such it is necessary to draw the tubes very hard, preceded preferably by relatively light anneals. This means excessive wear on the dies, an increased tendency toward scratching, an increased difficulty in meeting narrow dimensional tolerances, and an increase in manufacturing cost, for which the user has to pay, and for which he gets no return in increased life of the tube.

It should also be borne in mind that it is possible to make tubing of practically any desired grain size. The cost of the tubing, of course, varies in proportion to the strictness of the specifications. In justice to the consumer, however, who has to pay the bill, the specification should not include certain requirements unless it can be clearly shown that these will safeguard the user in the quality of his material or in the length of service of his tubes.

D. K. CRAMPTON,
Waterbury, Conn. Metallurgist.

## Another Method of Refitting a Worn Valve Rod

Commenting on the method of repairing Corliss engine valve stems, as described by W. A. Ford, in the Dec. 5, 1922, issue, I do not approve of drilling "holes" in the rod, as it tends to weaken it further. I have found the following method to give satisfactory results:




ROD IS TURNED DOWN, AND A LARGER SIZE PACKING IS USED

The valve stem is turned down, as shown in the cut. A split cup-washer *A* made of babbitt metal is first inserted into the stuffing box, which is then packed with a larger size of packing. I have found that the stems will last a long time after being refitted in this manner.

Hasbrouck Heights, N. J. G. J. LITTLE.

## What Is the Best Design of Firebox?

C. R. Hodgson raises an interesting point in his letter in the Nov. 21, 1922, issue of *Power*, in which he practically charges manufacturers of boilers with negligence in the design of fireboxes. He claims that boiler manufacturers pay little if any attention to the firebox, that their work begins and ends with the construction of the boiler, and as a result the purchaser of the boiler finds it necessary to build a fire under the boiler almost anywhere—wherever space may be left—and it is a sort of hit-and-miss proposition as to whether or not the boiler will be efficiently heated.

I cannot agree with Mr. Hodgson on this point. For a great many years the firebox or combustion chamber has been given serious consideration by all of the well-known boiler manufacturers, and they can and do advise the purchaser how to get the best results out of the fire that will be built under the boiler.

The fact that the Dutch oven type of furnace was first built many years ago and has been thoroughly tried and is still used in some instances, surely is proof that considerable study has been given to the matter of the firebox. If it had been found to be more efficient than the direct heating firebox, there is no doubt that

it would be used today in preference to our modern methods. The greatest objection to the Dutch oven is that the effect of radiant heat is lost, and that is also one of the arguments against the reverberatory type of furnace.

Mr. Hodgson gives as one advantage of the outside firebox the possibility of bringing the boiler down to a level with the firemen so that the water and steam gages would be accessible and visible. This in my opinion is a minor advantage, for it is possible to place the steam gage almost anywhere, and as for the water level, the fireman doesn't have to pay much attention to that if the boiler is equipped with the right kind of boiler-feed regulator. The modern method is to permit considerable variation, depending upon the load. It is common practice today to have indicators, charts, gages, etc., in the chief's office, which may be at a considerable distance away from the power plant. If it can be done for the chief, it surely can be done for the fireman. From my viewpoint the most important thing is to make the boiler safe enough and put it into a setting that is most efficient according to actual tests, and if the tests show that boilers of great height give better results than low boilers, I am in favor of building them high.

In recent years engineers and manufacturers have gone into the design and the making of steam boilers more scientifically. The United States Government has assisted with tests. Boiler manufacturers themselves have spent a great deal of money devising ways and means to improve efficiency and increase capacities. As a result boilers are more efficient today than ever before. They are being built higher. Fireboxes are made larger. Plenty of room is allowed for complete combustion and efforts are made to absorb the maximum of radiant heat from the furnace. F. M. REILLY.

Newark, N. J.

## Improvements at Plant of International Motor Company

Referring to the letter of William F. Ryan, appearing in *Power* of Jan. 16, 1923, more complete information may be of interest.

Mr. Ryan claims that the actual coal consumption for the period in question was 11,854 tons. Our records show that 12,738 tons were consumed. The discrepancy might be accounted for by the fact that our evaporation and other records are computed on the basis of a standard ton instead of a long ton, and for the purpose of making an intelligent comparison with our operations this was transferred into standard tons. Mr. Ryan's records very likely are on the basis of long tons.

In the second paragraph reference is also made to the fact that coal at that time was of such a poor quality that it was carted to the dump. We can verify this fact because, when the plant was acquired, there was approximately 4,000 tons of coal in this heap, and as far as we were concerned it represented money. Therefore, the management insisted on having it burned, regardless of complaints from firemen and men in charge of power-house operations. The coal consumed during the winter of 1921 and the spring of 1922 was this 4,000-ton heap. This is borne out further by our records, which show that from Jan. 1921, to March 1, 1922, a total of 485 tons only was purchased. The record, therefore, was built up on the coal which was "carted to the dump," and not on a select quality of coal, as is assumed by Mr. Ryan.

It is impossible to say what the calorific value was of the coal fired in June, giving 10.65 lb. water per pound of coal. This was purchased coal and was not analyzed. The following table, however, gives a better idea of actual evaporation so far this year and indicates unusual conditions in June.

RECORD OF EVAPORATION IN 1922

| | Lb. Coal Consumed | Lb. Water Evaporated | Evaporation Lb. Water per 1 Lb. Coal |
|---|---|---|---|
| January | 1,766,500 | 12,712,000 | 7.19 |
| February | 1,457,200 | 12,614,500 | 8.68 |
| March | 1,146,200 | 10,177,500 | 6.96 |
| April | 670,800 | 5,298,500 | 7.88 |
| May | 605,550 | 5,983,000 | 9.88 |
| June | 687,000 | 7,318,500 | 10.65 |
| July | 815,200 | 6,352,000 | 7.79 |
| August | 700,000 | 6,187,000 | 8.83 |
| September | 606,400 | 4,868,000 | 8.02 |
| October | 508,700 | 5,256,500 | 10.33 |

The fact that the previous management purchased large amounts of current from the public service company (mentioned in par. 3) does not necessarily imply that more steam was then used for power generation, because at that time there were demands for considerable direct current, which was furnished by a motor-generator set during the summer or non-heating months. This is probably the most economical way of taking care of the direct-current requirements in the limited quantities to conserve coal. Shortly after taking over the plant, an emergency arose at the Plainfield plant, whereby it was necessary to transfer this motor-generator unit to it and we were obliged to take care of our direct-current requirements during the summer months through our steam-driven units, which if anything, would call for burning more coal. In other words, by using purchased current to develop direct-current power, it obviously should have been possible for Mr. Ryan to furnish this current without any coal consumption.

Regarding paragraphs 4 and 5, it is my impression that during the old régime compressed air was developed with the aid of two large motor-driven compressors and two steam compressors. The motor-driven compressors were used more than the steam compressors during the summer months. Again, after taking over the plant, the large 888-cu.ft. motor-driven compressor was delivered to the Allentown plant, which made it necessary for us to put into condition the large steam-driven compressor, and the air we furnished for our requirements was generated principally by steam-driven units. We believe that our demands for air are fully as great as they were at any other time. In addition to using air in our foundry operations, it is used in the machine shop for air chucks, etc.; many more of these are used than by the old management. We also operate several large sandblasting machines, which, it is well known, consume large quantities of air. We are operating only one steam hammer less than were operated previously.

Paragraph 6 brings up the question of the actual number of men on the payroll. The power-house records show that there were 28 men on the payroll and at times 32. This number included firemen, coal passers, engineers and oilers, also a boilermaker. All the steam units in the power house are being operated to full capacity—more so, if anything, than ever before—and the number of men on the payroll is eight, including the chief engineer, engineer, firemen and coal passers. In the 28 to 32 men are not included pipefitters, maintenance men, etc., whom it was necessary to keep working during the winter months keeping the system in repair. A. J. MORRISON,

New Brunswick, N. J. Works Engineer.

# QUESTIONS AND ANSWERS

Conducted by Franklin VanWinkle

### Operating Synchronous Motors at Reduced Loads

We have a 175-hp. synchronous motor driving a duplex double-acting ammonia compressor. During the winter months one side of the compressor is disconnected, as the full capacity of the machine is not needed. I would like to know if operating the motor under weakened field to give about 0.50 power factor lagging is the most economical? F. B. W.

From a purely power-consumption point of view the most economical power factor is 100 per cent under all conditions of load. However, where a bonus is paid for high power factor, it might be economical to operate the motor with its field overexcited and supply a leading current to the power system.

### Power and Mechanical Efficiency of Engine

An engine having a cylinder 8 in. diameter and stroke 18 in., makes 150 r.p.m. The mean effective pressure of the steam is 35 lb. When tested by a 5-in. diameter brake pulley on the crankshaft, the effective load on the brake is 249 lb. with a radius of 2½ ft. What is the indicated horsepower; brake horsepower; and the working efficiency of the engine? P. W. W.

The indicated horsepower would be

$$\frac{35\times(18\div12)\times(8\times8\times0.7854)\times(2\times150)}{33{,}000}=24 \text{ i.hp.}$$

The diameter of the brake pulley would be immaterial. With an effective load of 294 lb. acting at a radius of 2.5 ft., the brake horsepower developed would be

$$\frac{(2\times2.5 \text{ ft. radius}\times3.1416)\times294 \text{ lb.}\times150 \text{ r.p.m.}}{33{,}000}$$

$$=21 \text{ b.hp.}$$

The "working" efficiency (generally called "mechanical" efficiency) would be the fraction of the indicated power that is converted into brake power. That is, the working or mechanical efficiency would be $\frac{21}{24}$ or $(21\times100)\div24=87.5$ per cent.

### Capacity of Galvanized Pipe Line

How much water (gallons per minute) will flow through a 2½-in. ordinary galvanized pipe, 2,000 ft. long with a pressure of 25 lb. per sq.in. at the entrance of the pipe? Also, if the pipe is to be 2,000 ft. long and the head 25 lb. per sq.in., how large must the pipe be to furnish 40 gallons per minute?

The rate of flow in a water pipe depends on the difference of pressure at the entrance and exit, the roughness of the interior pipe surface, the actual internal diameter of the pipe, and the length of the pipe. As only the entrance pressure is stated, it is assumed that the discharge pressure is to be 0 lb. above the atmosphere and that all the head pressure at the entrance is to be used up in overcoming pipe friction and friction at the entrance.

"Ordinary" galvanized pipe is extremely variable in roughness and actual internal size, due to lumps of galvanizing material left on the inside of the pipe, which sometimes reduces the clear way to one-half of the nominal size. With a clean full bore of 2½ in. diameter, a pipe 2,000 ft. long and 25 lb. per sq.in. pressure at the entrance, and discharge taking place at only atmospheric pressure, the discharge would be about 70 gal. per min.

Under the same conditions of length, smoothness and pressure at the entrance, 40 gal. per min. would be discharged at the pressure of the atmosphere by a 2-in. pipe. For a discharge pressure of 12 lb. per sq.in. a 2½-in. pipe would deliver about 50 gal. per min.; and a 2-in. pipe would deliver about 25 gal. per min.

### Determination of Oil in Boiler-Feed Water

How can determination be made of the presence of oil in boiler-feed water that may have become contaminated with engine oil deposited out of the exhaust in an open feed-water heater?

H. G. M.

If oil is present in the water, the addition of a sufficient quantity of a concentrated solution of caustic soda, shaken up with the water in a test tube, should produce a turbid appearance, forming a soap on the surface of the mixture after being allowed to stand for a short time. To make a fair test of the amount of engine cylinder oil contained in a sample of the feed water as compared with the raw water, take equal quantities of the raw water and of the feed water. Note the amount of caustic-soda solution that must be added to the sample of feed water to produce turbidity, and add the same amount of the caustic-soda solution to the sample of raw water. Then note the quantity of engine oil that must be added to the raw-water solution to bring it to the same appearance as obtained with the feed-water sample. This will approximately demonstrate the greater amount of oil present in the original sample quantity of feed water.

For chemical laboratory determination of oil: Add to 2 liters of the water (contained in a 2½-liter flask) 5 c.c. of the "ferric chloride" solution and heat up nearly to boiling; then add ammonia in excess to precipitate the iron (which precipitate contains all the oil) and boil for two minutes. Allow to stand a few minutes and filter through 15-cm. filter paper which has been previously extracted with ether, washing the precipitate onto the paper three or four times with hot water. Then dry the filter and precipitate in a water oven at 100 deg. C. and, when dry, extract with ether in the Soxhlet apparatus, evaporate the ether extract, and weigh the remaining oil. The ferric-chloride solution consists of ten grams of iron dissolved in 200 c.c. of hydrochloric acid, oxidized with $HNO_3$, and made up to 1 liter.

## Variation of Oil Engine Power with Altitude

**Why does the horsepower of an oil engine decrease with an increase in altitude? How much is the decrease? R. A. C.**

The horsepower developed in the cylinder of an oil engine depends upon the amount of fuel supplied the cylinder. In turn, the amount of oil that will be completely burned is dependent upon the amount of air present. Oil of average characteristics requires theoretically 13.5 lb. of air per pound of oil. Since it is impossible to have each particle of fuel mix with the exact amount of air, there must be an excess supply, say 50 to 70 per cent over the theoretical requirement. This means that a pound of oil will need from 20 to 23 lb. of air.

The weight of one cubic foot of air depends on the pressure of the air. The weight of a given volume is found by the equation $PV = MRT$, where $P$ = lb. absolute pressure per sq. foot, $V$ = volume in cu. ft., $M$ = weight of the air, $T$ = air temperature in deg. absolute (460 F. reading), and $R$ = a constant (53.2 for air).

It will be noticed that with a unit volume of air the weight will vary directly with the absolute pressure.

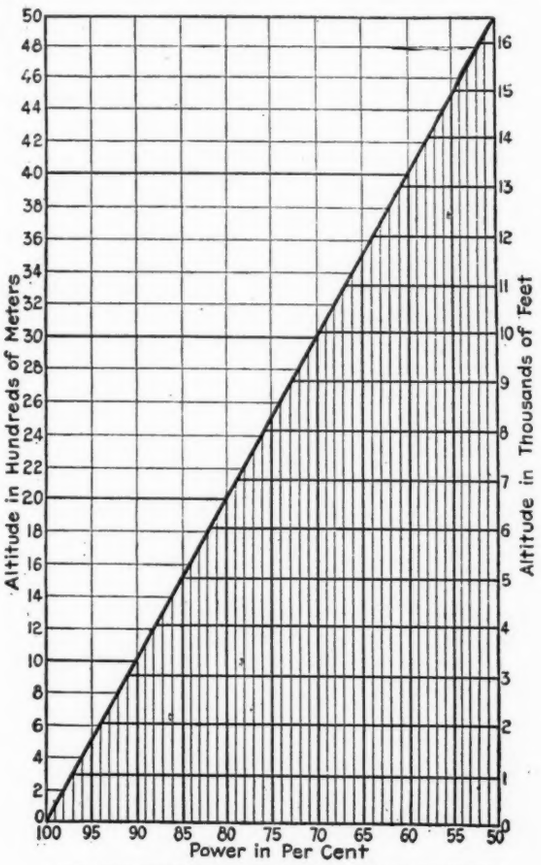


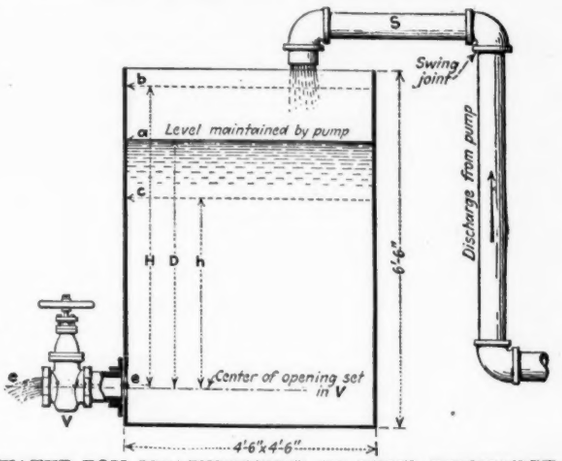

CHART SHOWING DECREASE IN POWER WITH INCREASE IN ALTITUDE

If the pressure is less than usual, the cylinder of an oil engine will then draw in less weight of air and less oil is burned. Since the pressure at sea level is 14.7 lb. per square inch absolute, if the plant is located high enough above sea level to cause the atmospheric pressure to be one-half this amount, the decrease in engine power will be one-half. The chart shows the allowances that are usually made for altitudes above sea level.

## Water-Box Measurement of Pump Discharge

**A mine pump discharges at the surface into a water box that is about 4 ft. 6 in. by 4 ft. 6 in. and about 6 ft. 6 in. high. As shown in the sketch, the sides are vertical and there is a 6-in. gate valve in one side of the box near the bottom by means of which the water level can be varied. The pump delivery is about 750 gal. per min. How can the rate of discharge be tested? M. S.**

Set the discharge valve $V$ to the amount of opening that is found necessary for holding the level in the water box to a point $a$ that is about 4 ft. 6 in. above




WATER-BOX MEASUREMENT OF PUMP DISCHARGE

the center of the valve opening. Mark this point on the inside of the water box. Then, without changing the adjustment of the valve, shut off the pump and make a mark $b$ that is about 12 in. above and another mark $c$ that is about 12 in. below the level of the water that was maintained with the pump running. Without changing the valve, but with the outlet side of the valve partly obstructed, fill the box to the upper mark $b$ and, with the supply cut off by swinging pipe $S$ to one side and with the discharge taking place through the unobstructed valve with the adjustment still the same as when the level was maintained by the pump, note the lapse of time, in minutes and seconds, required for the level of the water to fall from the upper mark $b$ to the lower mark $c$.

Then if $e$ is the level of center of opening at which the valve was set, the rate of discharge when the head is maintained at the level $a$ is given by the formula,

$$\text{Gallons discharged per second} = \frac{L \times B \times 0.00867}{T} \times (\sqrt{H} - \sqrt{h}) \times \sqrt{D}$$

where

$L$ = Length of water-box in inches;
$B$ = Breadth of water-box in inches;
$T$ = Time in seconds, required for the level of water to fall from $b$ to $c$;
$H$ = Height of $b$ above $ee$ in inches;
$h$ = Height of $c$ above $ee$ in inches;
$D$ = Height of $a$ above $ee$ in inches.

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[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

# Easy Lessons in Engineering

## How Many Decimal Places?

"How many decimal places?" is a question of considerable practical importance, yet many engineers have hazy notions about it. If too many decimal places are used time is wasted, while if too few are used the answer is not as accurate as it should be. The schools often teach arbitrary rules such as: "Carry all computations to four decimal places." That this rule is entirely impractical may easily be seen by considering a few examples.

Let us say that a man is interested in finding the amount of water a certain tank holds and figures it to be 1,256.2932 gal. The .2932 is a joke to everyone except the poor fellow who had to sweat over the arithmetic. In the first place let us admit, purely for the sake of argument, that the data from which the volume is computed are absolutely accurate. What practical difference does it make whether the tank holds 1,256.2932 gal. or 1,256.3 gal.? In most cases what practical difference would it make if we said that the tank held 1,260 gal.? Here is a case where four decimal places is at least four too many.

Now for the opposite condition! Suppose that it is desired to figure the cost of steam in dollars per pound, and that the result obtained is $0.000548. If we want to find the cost of 1,000,000 lb. of steam, the exact multiplication would give:

$$1{,}000{,}000 \times \$0.000548 = \$548.$$

If we followed the "school-days" rule of four decimal places, we would get the cost as:

$$1{,}000{,}000 \times \$0.0005 = \$500.$$

This makes a difference of $48, or nearly 10 per cent of the total amount involved. Evidently, this is a place where at least five or six decimal places are needed.

The case of using too few decimal places does not occur as often in engineering work as that of using too many. Ordinarily (but not always) the unit employed is of such a size that four decimal places are more than enough.

The trouble with most thinking along this line is that too much stress is laid on decimal places. What should usually be considered is places of "significant figures." The significant figures of any number are all the digits, starting with the first digit that is not a zero. In the following examples all the underlined digits are "significant figures:"

EXAMPLES

| Number of Significant Figures | (Significant Figures are Underlined) | | |
|---|---|---|---|
| 1 | 3. | 0 3 | 0.0003 |
| 2 | 3.4 | 0 34 | 0.00034 |
| 3 | 3.40 | 0.340 | 0.000340 |
| 4 | 3.407 | 0.3407 | 0.0003407 |
| 5 | 3.4070 | 0 34070 | 0.00034070 |
| 6 | 3.40702 | 0.340702 | 0.000340702 |

With any of the numbers given, if we start at the left and begin counting when we reach the first digit that is not a zero, and after that count all the digits including zeros, we shall find the number of significant figures indicated in the column at the left.[1] Probably 95 per cent of engineering computations could be properly handled with five or less significant figures and 50 per cent with four or less.

The number of significant figures is closely related to the percentage of error, while the number of decimal places is not. For this reason the number of significant figures is the important thing in most problems. Suppose that the number under consideration is 0.1915 and that it is written with only one significant figure as 0.1. Then the error is 0.1915 — 0.1000 = 0.0915. This is nearly 50 per cent, which is the worst possible error with one significant figure. In this example we put down the first digit as it stood. Usually, the size of the next digit is considered in determining the value of the last significant figure. In that case the possible error is smaller. The number 0.1915, if carried to one significant figure, would ordinarily be written as 0.2. Here the error amounts to about 5 per cent.

The best way to see how much error is caused by dropping figures is to look at the actual number under consideration. Suppose that it is 10.3746. This number has six significant figures. If it were written with five significant figures, as 10.375, the error would amount to 0.0004 out of 10.3746, which is 4 out of 103,746 or approximately one part out of 25,000. Next, suppose another digit is dropped and we write the number as 10.37. The error is now 46 out of 103,746, or approximately one part out of 2,000. This is the worst error that can be obtained with four significant figures. The largest error occurs when the first significant figure is 1 and the last digit thrown away is 5. The smallest errors occur where the first significant figure is 9 and the one thrown away is 1 or 9. For example, if 99.7513 is written as 99.75, the error is 13 parts out of 997,513, or approximately one part in 100,000. The error is practically the same if 99.7587 is written as 99.76. That it is the significant figures that count rather than the number of decimal places, may be seen by considering the number 0.0000997513. In this case, if we used only four *decimal places* we would have .0000, which is ridiculous. If, on the other hand, we used four *significant figures* we would have .00009975. The error would be 13 parts out of 997,513, or approximately one part in 100,000 as before. In other words, the error expressed as parts in 100,000 or as a percentage is entirely independent of the num-

[1] In certain cases, where the number is greater than 10, this rule cannot be followed literally. For example, if it is desired to carry the number 340,702 to three places of significant figures, it evidently cannot be written 341. In this case one must write 341,000. The person who writes this number knows that the real number of significant figures is three, but someone else might take it to be six. This does not cause much confusion in practice. If, for instance, the population of a town is given as 9,000, the chances are there is only one or, at the most, two significant figures. If the population is given as 9,300, there are probably two or, at the most, three significant figures.

ber of decimal places and depends only on the actual digits and the number of significant figures.

The following table shows the maximum error that can occur with various numbers of significant figures for the two extreme cases where the first significant figure is 1 and where it is 9.

| Number of Significant Figures | Approximate Value of Maximum Possible Error Where First Significant Figure Is 1 | First Significant Figure Is 9 |
|---|---|---|
| 1 | 1 part in 3 | 1 part in 18 |
| 2 | 1 part in 20 | 1 part in 180 |
| 3 | 1 part in 200 | 1 part in 1,800 |
| 4 | 1 part in 2,000 | 1 part in 18,000 |
| 5 | 1 part in 20,000 | 1 part in 180,000 |
| 6 | 1 part in 200,000 | 1 part in 1,800,000 |

Where the first significant figure is between 1 and 9, the possible error will lie between the values given. It must be remembered that the table represents the worst possible conditions and that the average errors will be much less than those shown. As a typical example take the number 19.4362. If this is written to four significant figures, as 19.44, the error is 38 out of 194,362, or approximately one part in 5,000.

The practical conclusion from all this is that if one must have a rule, he should discard that about using four or any other fixed number of decimal places in all computations, and adopt a new rule to use (say) five significant figures where the first is 5 or less and four significant figures where the first is larger than 5. Even this rule is a sort of makeshift, although it is about right for most engineering computations.

The best thing to do is to consider the actual computations to be made and see, first, how close an answer is desired, and second, how close an answer is possible. It is certainly a waste of time to get an answer that goes several places beyond what the accuracy of the data justifies, or the nature of the problem requires.

Suppose it is desired to figure the number of cubic inches in a board that measures $8\frac{3}{4}$ in. wide, 3 ft. $5\frac{3}{8}$ in. long and $1\frac{3}{8}$ in. thick. Reduced to inches and decimals, the three dimensions are as shown in column *B* of the following table:

| | *A* As Read From 4-Ft. Rule | *B* Reduced to Inches and Decimals | *C* Carried as Far as Measurements Justify | *D* Figures To Use in Computation |
|---|---|---|---|---|
| Width..... | $8\frac{3}{4}$ in. | 8.75 | 8.75 | 8.75 |
| Length..... | 3 ft., $5\frac{3}{8}$ in. | 41.375 | 41.38 | 41.4 |
| Thickness..... | $1\frac{3}{8}$ in. | 0.9375 | 0.94 | 0.94 |

Most people would next proceed to multiply $8.75 \times 41.375 \times 0.9375$, and carry the final result to at least four places of decimals. This is a waste of time, even where it is desirable to have the answer as close as possible. There is no use in figuring much closer than the accuracy of the measurements justify. Assume that the measurements can be trusted to $\frac{1}{64}$ in. Then there is no excuse for carrying the results further than shown in column *C*. The changes from column *B* amount to zero for the width, five thousandths of an inch for the length and two and one-half thousandths of an inch for the width. Certainly, no practical man could object to this, considering what he is measuring and the scale he is using.

But it is possible to simplify these numbers still further before multiplying. On a percentage basis the least accurate of the three measured dimensions is the thickness, which (as just shown) is only worth using to two significant figures. Even if the width and length are reliable enough to justify using three and four significant figures respectively, when considered by themselves, it must be remembered that, when the three dimensions are multiplied together, any error in the thickness will produce the same percentage of error in the final product. Since the error in the thickness is large in comparison with that in the width and length, it is not worth while to have the two latter very much more accurate than the width. To play safe, allow three significant figures for the length and width, as shown in column *D*. This insures that the errors in length and width will be of no consequence in comparison with the much larger error in the thickness. We may now multiply $8.75 \times 41.4 \times 0.94$ to get the volume. The operations are as follows:

$$8.75 \times 41.4 = 362.25$$
$$362.25 \times 0.94 = 340.515$$

This should be written 341 because more significant figures would be meaningless and give a false impression of accuracy. A good rule to follow where only multiplication and division are involved is to carry the answer to one more significant figure than that original number with the fewest significant figures.

It would be proper to ask why the first product, 362.25, should not be shortened before multiplying by 0.94. As far as the error in the answer is concerned, it might properly be reduced to 362.2 or even to 362, before multiplying by 0.94. This, however, would make it impossible to get an exact check of the answer by the methods shown in the article, "How To Avoid Mistakes in Arithmetic," published in the Jan. 9, 1923, issue of *Power*.

Scientific men make a distinction between an error and a mistake. An error is an unavoidable or unimportant difference due to the fact that no measurement can be absolutely exact, or that some unimportant figures or facts have been neglected. A mistake, on the other hand, is an actual slip in arithmetic. Mistakes must be eliminated, while errors must be kept within practical limits.

An arithmetical check to reveal mistakes is more reliable if it is so made that the two answers are exactly alike. For this reason it is generally better not to drop any figures after starting the actual computation. Nevertheless, a check reliable enough for many purposes can be obtained even where digits are dropped during the computation and checking. For example, in the case under consideration we might proceed as follows:

Solution:

$8.75 \times 41.4 = 362.25$, say 362
$362 \times 0.94 = 340.28$, say 340

Check:

$875 \times 0.94 = 8.225$, say 8.23
$8.23 \times 41.4 = 340.722$, say 341 (approximate check).

The final answer might be written either as 340 or 341, the difference being immaterial in this particular problem.

This brings up the whole question of accuracy. In practical affairs accuracy is all relative. There is no such thing as an absolutely exact measurement. Since most engineering work is based on measurements, exact computed results are rarely possible. We can, it is true, say that the area of a 2x4-ft. rectangle is exactly 8 sq.ft., but such a rectangle will never exist outside of the imagination. The important thing is to keep the error in measurements and computations small enough so that the difference is of no practical importance in the particular job. Since the permissible error in a measurement may vary all the way from a ten-thousandth of an inch to a foot or more, common sense is the chief requisite for deciding what accuracy is needed.

# The Design of Structural Supports for Turbo-Generators

THE relative merits of the three common types of foundations or pedestals for steam-turbine units—reinforced concrete, structural steel and composite construction—are discussed by E. H. Cameron, in an interesting paper presented at the Dec. 20, 1922, meeting of the American Society of Civil Engineers. The restraint of vibration, provision for repair of auxiliaries, and the restriction of deflections to a very small amount should be the controlling factors of design. It is suggested that a definite allowance should be made for horizontal impact that might possibly be due to vibration under abnormal conditions, in addition to the allowance for vertical impact which is now generally used.

The author suggests that the sole basis of comparison in deciding on a type of pedestal for a turbo-generator installation should be utility or fitness, rather than relative cost.

Introduction of the turbine-driven generator set has caused the evolution of a distinct type of foundation, which allows a comparatively light and open pedestal in comparison with that required for the original reciprocating unit. Generally, the horizontal impacts due to reciprocating motion are absent in turbines. On the other hand, special requirements for foundations regarding the necessity of

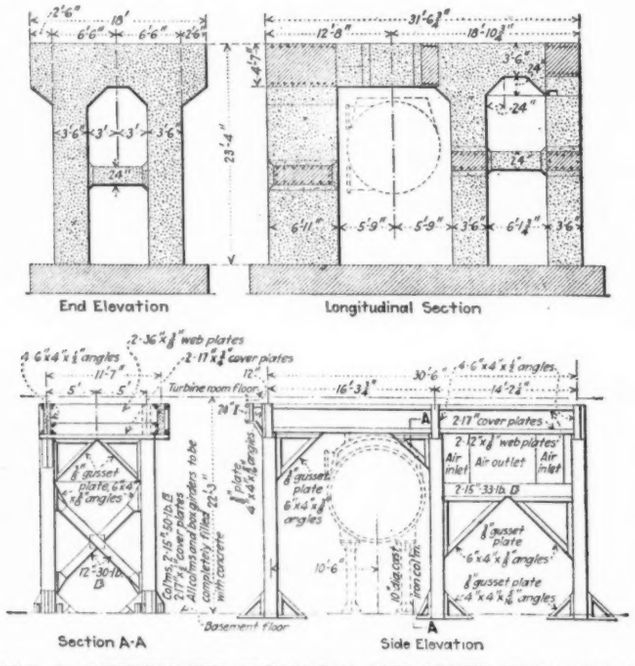


FIG. 1—REINFORCED-CONCRETE AND STEEL PEDESTALS RECOMMENDED BY MANUFACTURERS

limiting vibration and allowing for abnormal conditions in the prime mover have made themselves felt.

The foundation ordinarily consists of two elements: the sub-foundation consisting of the mat or footing on which the structure rests, and the steel or concrete element, usually termed the pedestal, between this and the level of the unit. The type of the condenser has a great deal to do with the design of the pedestal, which is simpler in the case of the jet condenser, where less room is required than in that of a surface condenser when placed under the prime mover, the latter condition often requiring great ingenuity on the part of the structural designer, in order to prevent interference of braces with the condenser equipment.

The reinforced-concrete pedestal is probably the most common type in use. Its advantage lies in the relatively great volume of concrete on the beams and piers, which has sufficient mass to absorb any vibration that may develop in the machine, and to the fact that the steel is covered with concrete, making the structure less liable to unequal expansion by its various members, due to non-uniform temperature conditions of the turbine room. The disadvantages include a restricted space for the condenser, and interference with ventilating air ducts, piping, etc., on account of the volume of concrete. The weight is several times as great as that of a steel pedestal, which results in a more expensive sub-foundation, or mat.

There is no sharp line of demarcation existing between steel and composite pedestals. The latter type usually is

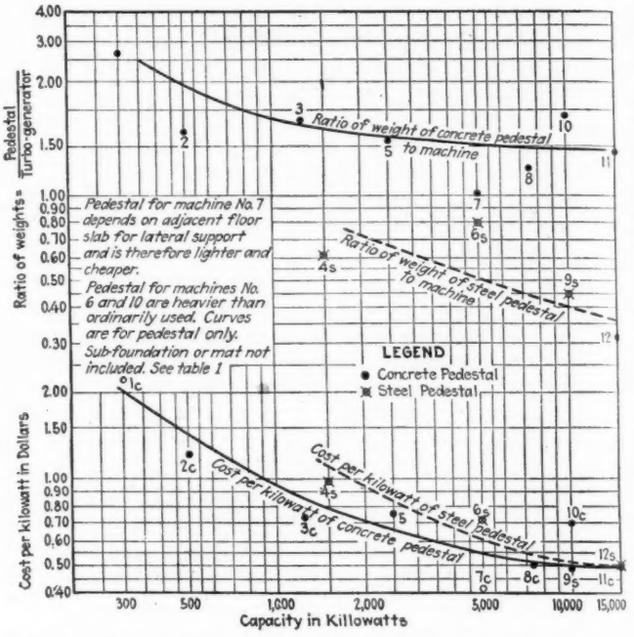
Ratio of weights = Pedestal / Turbo-generator
Ratio of weight of concrete pedestal to machine
Ratio of weight of steel pedestal to machine
Pedestal for machine No. 7 depends on adjacent floor slab for lateral support and is therefore lighter and cheaper.
Pedestal for machines No. 6 and 10 are heavier than ordinarily used. Curves are for pedestal only.
Sub-foundation or mat not included. See table 1
LEGEND
Concrete Pedestal
Steel Pedestal
Cost per Kilowatt in Dollars
Cost per kilowatt of concrete pedestal
Cost per kilowatt of steel pedestal
Capacity in Kilowatts

FIG. 2—STEEL PEDESTALS WEIGH LESS AND COST MORE

understood to refer to a pedestal whose main members are of structural steel, while concrete filling is placed between the girders, with a concrete mat or floor in most cases on the top of the structure. This represents an easier problem for the designer than a reinforced-concrete structure.

The structural steel pedestal is a desirable type from the point of view of space required, but it has a tendency to vibrate at a speed approximating that of the turbine, even if the structure is liberally designed in regard to strength. Unequal expansion of the various members is more easily caused by discharge of steam, hot vapor, etc., taking place in the turbine room. Fig. 1 represents concrete and structural-steel pedestals such as were recommended by two different manufacturers.

In regard to overcoming the tendency to vibration, the effect of mass is very important, which will consume the energy causing vibration and act as a flywheel in imparting the work from one direction to that received when vibration is in the opposite direction.

In studying the mass required for foundations, Fig. 2 shows weight of pedestals as obtained from practical examples. These indicate that concrete designs as now made, weigh two to four times as much as those of steel. For both types, the weight ratio decreases as the units become larger. These curves are not intended to give the precise weights or costs in any instance, as the sources of information are too diverse for such conclusions. The factors vary in different cases, and the only way to plot curves of absolute commercial values would be to design

foundations for a particular type or set of conditions, for a number of sizes of units. Cross beams or other bracing must be introduced to prevent swaying oscillation and to make the columns capable of resisting bending. The forces caused by vibration may be roughly proportioned to the mass of the turbine and generator, and to its acceleration in the direction of vibration. By making certain assumptions as to the amplitude of the vibrations and their frequency, it is possible to derive an expression giving the relation between the weight of the turbo generator and the force that it exerts in the direction of vibration or sway. Thus $F = \frac{K}{100} W$ where $F$ is the force due to acceleration and $W$ is the weight of the unit.

In determining $K$, practical considerations should govern, such as those based on design assumptions which are found to give satisfaction in existing installations. $K$ will not vary with the speed, but will have a maximum value at the critical speed and be much less at lower or higher speeds. Other indefinite factors governing $K$ are changes in steam pressure, temperature, and in the balance of the unit.

The impact allowance $K$ is a percentage of the dead weight of the machine acting as horizontal or vertical forces at the top of the pedestal. For ordinary designs the writer has used horizontal and vertical impact allowances varying from 33⅓ to 50 per cent of the dead weight.

Every pedestal has a period of free vibration, which is a definite time that would elapse during one complete oscillation if the pedestal were sprung from its normal position and left free to oscillate without receiving further exterior impulse. This depends on size, length and arrangement of its members and the material of which they are constructed, as well as the rigidity of the joints. This factor cannot be calculated with practical success. The more rigid a pedestal is made, the shorter its period will be, giving better operation as a rule, so that its members should be arranged to secure this end.

A lower center of gravity is obtained in some instances by suspending the condenser from the machine at the top, so that its mass is added to that of the unit.

When the natural period of vibration of a pedestal is the same as that of the turbine, vibrations are easily magnified by the foundation, and the least tendency of the turbo-generator to vibrate may result in disastrous trouble. Longitudinal bracing is desired in order to prevent vertical impact due to vibration. Short-circuit or misalignment of the generator may cause an unequal side pull or violent fluctuation in speed. A detailed discussion of design of a pedestal is included. In keeping deflections as small as possible, a common value for maximum allowable deflection is 0.02 in. A thick concrete slab gives good results on top of a steel structure. Provisions should be made for future repairs of the turbine unit and condensing apparatus, so that the foundation will not be in the way. It is generally considered advisable to isolate the pedestal and footing from the remainder of the power plant, so as to avoid vibration being transmitted to the various floors and other parts of the power house as much as is possible.

For ordinary designs the cost of the pedestal should not exceed 5 per cent of that of the turbo-generator, and in general any saving of one particular pedestal over another will not be more than 1 per cent of the cost of the unit that it supports. Costs, therefore, play a comparatively minor part in determining the type of foundation.

## Convention of Marine Engineers Beneficial Association

Five years ago the Marine Engineers Beneficial Association, after forty-three years of existence as an independent organization, affiliated with the American Federation of Labor. The results of a referendum announced on the assemblage of its forty-eighth annual convention were overwhelmingly in favor of a return to its old independent status.

The convention was called to order on Monday, Jan. 15, at the Franklin Square Hotel, Washington, by President William S. Brown, with less than the usual number of delegates present, but with plenty of optimism and faith that the association is headed toward better days and greater usefulness and that it will complete its half-century of service in a commanding position.

The president's address dealt with the activities of the association during the last year, and in addition to the reports and messages of its other officers the association listened to addresses by Hon. J. J. Davis, Secretary of Labor; J. A. Jenkins, of the Industrial Relations Department of the United States Shipping Board; and George Uhler, Supervising Inspector General of the United States Steamboat Inspection Service.

Resolutions in support of the Ship Subsidy bill were passed. Although vitally interested in the development and prosperity of the merchant marine, the motive of self-interest which may be imputed to this action should be tempered by the consideration of the exceptional and intimate knowledge that these members of the marine personnel of the nation have of the difficulties and requirements of that service.

The officers of the association were instructed to oppose vigorously Senate Bill 4093, providing for the use of a continuous discharge book for seamen. This involves the approval by the master of a vessel of the qualifications, conduct and service of the holders of the books, and the engineers hold that, being licensed as qualified officers, they should be subjected to no such further supervision in common with subordinate members of the crew.

A proposition from a life insurance company for blanket life insurance for the membership received favorable consideration and was referred to the Executive Committee for investigation and recommendation.

On motion of Secretary Grubb the Cleveland delegation was requested to call upon William Kennedy, of Buffalo, one of the few members still living who attended the first convention of the association in 1875, and to convey to him the greetings and good wishes of the convention.

Arrangements were made for conferences between committees and the Board of Supervising Inspectors, the Public Health Officials and officials of the Shipping Board.

The election resulted in the continuance in the office of William S. Brown as president, George A. Grubb as secretary-treasurer and David W. Miller, W. H. Hyman and Samuel S. Hogan as first, second and third vice-presidents respectively. The executive committee chosen consists of: W. H. Hyman, Baltimore, Atlantic Coast; John R. Floud, San Francisco, Pacific Coast; William J. Garratt, Buffalo, Great Lakes; Charles M. Sheplar, Pittsburgh, Rivers; Samuel S. Hogan, New Orleans, Gulf.

The ladies, of whom a considerable number were in attendance, were entertained by a visit to Mount Vernon, visits to the Cochrane Art Gallery and other institutions, theater parties, and a party at which A. Warren France was the host. The usual reception by the President was precluded by Mr. Harding's illness. The principal item of the entertainment program was the annual smoker in the Ball Room of the Willard, tendered by the supplymen.

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By modifying the furnaces under a set of boilers in one of the government heating plants in Washington, at a cost of about $1,000, and by controlling the boilers by the dampers instead of the ashpit doors and insisting that the boilers be fired regularly, the Bureau of Mines has cut the plant's annual coal consumption from 4,600 tons of anthracite and bituminous (anthracite was used to cut down smoke), at a yearly cost of $39,600, to 3,700 tons of bituminous alone, costing $27,000. The height of the bridge wall was changed slightly and an arch put over it, on the "wing wall" scheme, so that the combustion space was increased and time given the gases to mix and swirl, instead of passing straight through as formerly. Firebrick formed the chief item of expense in making the changes, as the labor was performed by the operating force. Bituminous coal is now burned alone without violation of the smoke ordinance. Experiments conducted over a period of months showed that prior to making the alterations the cost of anthracite was $0.7050 per thousand pounds of steam, and of bituminous coal $0.4225 per thousand pounds.

# News in the Field of Power

## Brazilian Federation Honors North Americans

One of the results most hoped for from the International Engineering Congress in Rio de Janeiro was the establishment of closer relations between the engineers of the Americas. A tangible proof that this has resulted is seen in the election of the following North American engineers to membership in the Club de Engenharia, an organization corresponding to an amalgamation of the four national societies in this country:

Josiah E. Spurr (A.I.M.E.) editor, *Engineering and Mining Journal-Press*, and Louis J. Hirt (A.S.M.E.) engineer, Pearson Engineering Corp., were elected corresponding members, while Verne L. Havens (A.S.C.E.), editor, *Ingeniería Internacional;* A. W. K. Billings (A.S.C.E.), Canadian & General Finance Co., Ltd. (Toronto); Edward Wegmann (A.S.C.E.), consulting engineer; Samuel M. Vauclain (A.S.C.E.), president, Baldwin Locomotive Works, and Calvin W. Rice (A.S.M.E.), secretary, A.S.M.E., were elected honorary members.

## High-Head Reaction Turbine for Oregon Project

A reaction turbine of 35,000 hp., operating under an effective head of 857 ft., will be the record-breaking initial unit of the Oak Grove hydro-electric project of the Portland Railway, Light and Power Co., one of the large developments now under way in the Northwest. The Pelton Water Wheel Co. is building the turbine, while a contract for the generating unit has been placed with the General Electric Co. The electrical unit will be of the vertical type, rated at 30,000 kva., 514 r.p.m., 11,000 volts, three-phase, 60 cycles, with direct-connected exciter mounted above the generator. It is planned to place the first unit in operation early in 1924.

The illustration gives an excellent idea of the amount of road-building necessary before any start may be made on the construction of a typical Western water-power project. A twenty-five-mile truck road had to be built through this sort of country, from the end of the Portland Railway, Light and Power Co.'s interurban railway line at Cazadero to the intake dam on the Oak Grove fork of the Clackamas River. For this project road construction alone represents an expenditure of about $800,000—a large item compared with the $3,000,000 to be spent on the first unit of the project. This road is now about 75 per cent completed, and will be finished early in the coming summer.

The building of two immense storage reservoirs will bring the ultimate cost to about $10,000,000. One of the noteworthy features of the project is that the water-storage possibilities are so great that the plant may be operated at full capacity for twenty-four hours a day, every day in the year.

## Propose Power House 25 Miles from Dam

A bold engineering scheme is embodied in the plan of the Colorado River Syndicate to build a dam 1,100 ft. high at Boulder Canyon or Black Canyon. This will mean the backing up of water into the lower edge of Grand Canyon National Park and the consequent flooding out of a number of small towns.

Another unusual feature is that the power house is not to be located at the dam, but at the end of a 25-mile tunnel, driven through the hard rock of the region. This tunnel will carry an average flow of 12,500 sec.-ft., requiring that the maximum capacity be twice that amount if the load factor is 50 per cent.

The scheme involves also the construction of a dam at Bull's Head Rock. This smaller development is to provide power for the construction of the larger project. The proposal is regarded with sufficient seriousness by the Federal Power Commission to provide for an immediate investigation of the entire project. W. G. Clarke is the consulting engineer.

## Brown Temporary Head of Bureau of Standards

Since a considerable period is likely to elapse before a director will be chosen for the United States Bureau of Standards, importance is attached to the designation by Secretary Hoover of Dr. Fay C. Brown as the acting director. Dr. Brown will direct the work of this important subdivision of the Department of Commerce during the interim.

Dr. Brown was born in Washington, Ohio, in 1881. He was graduated from the University of Indiana in 1903. He did graduate work at the University of Illinois, at the University of Chicago and at Princeton. After taking his doctor's degree at Princeton in 1908, he did further work at that institution as an Ogden fellow. On the completion of that work he accepted a position as instructor in physics and engineering at the University of Illinois. Later, he joined the faculty of the University of Iowa. He was engaged in that work when the United States entered the war. He entered the military service and was assigned to the Ordnance Department.

At the end of the war Dr. Brown had the opportunity to choose between the professorship of physics at the University of Iowa and the position of assistant director of the Bureau of Standards. He accepted the latter post.

ROAD-BUILDING FOR A WESTERN HYDRO PROJECT

Eight hundred thousand dollars went into the building of this 25-mile truck road for the $3,000,000 Oak Grove project. Sometimes it is necessary to cut roads through fifty to seventy-five miles of mountainous country in order to reach the power site.

## Tells of Italy's Water Power

**New Ambassador Outlines Developments at F.A.E.S. Banquet—Rice and Sperry Speak**

RAPID strides in water-power development are being made in Italy, declared Prince Gelasio Caetani, new Italian ambassador to the United States, in an address at the annual dinner of the American Engineering Council, Federated American Engineering Societies, held on Jan. 11 at the Chevy Chase Club, Washington, D. C. Co-operation between Italy and the United States will, he believes, lead to remarkable results, since the people of both are industrious and have an inventive, engineering turn of mind. However:

Much is still to be done in Italy itself; its resources are far from being fully developed and there are many opportunities for American capital, machinery and technical organization. The water-power industry in our country has made rapid strides. At present the use of "white coal" results in an economy of about two billion lire, otherwise necessarily spent on fuel imports.

In 1898 the electric energy developed in Italy amounted only to 87,000 kw.; it increased to 426,000 kw. in 1908, to 1,240,000 kw. in 1918, and power plants for an additional million kw. are planned or under construction. About 800,000 kw. are still to be developed.

A reservoir of 550,000,000 cu. yd. capacity is being constructed on the Tirso River, in Sardegna. Ranking just below the Assuan Dam in size, it will be the second largest in the world and will develop some 50,000,000 kw.-hr. and irrigate 60,000 acres.

The newly redeemed provinces in northern Italy are virgin ground for hydro-electric engineering because Austria for political reasons, prevented the development of power plants that could have an outlet only toward Italy.

In the Trentino a reservoir of 235 million cu.yd. capacity is to be constructed. The dam, 400 ft. high, will be practically a concrete wedge driven in a mountain gully, measuring less than 60 ft. width at the base and only 100 ft. wide at a height of 300 ft. In southern Italy the large reservoir in construction on the Sila Mountain will develop over 110,000 kw. and irrigate large tracts of fertile land.

Another interesting plan gradually being carried out is to connect the northern power plants, fed by the summer streams of the Alps, with those of central Italy, where water is plentiful in winter and rather poor in summer, by a network of high-tension lines, thus obtaining a better seasonal compensation than could be secured by the use of even very large reservoirs.

Among the other speakers were Calvin W. Rice, of New York, secretary of the A.S.M.E., Elmer A. Sperry and John J. Tigert, United States Commissioner of Education. Through the efforts of the Department of Commerce, Mr. Rice reported, the idea of standardization was spreading in the South American countries, all of which are contemplating legislation to establish a Standardization Bureau, as recommended by Secretary Hoover.

A permanent organization to carry out the resolutions of the recent International Engineering Congress at Rio de Janeiro has been effected, according to Mr. Rice, who said it was now proposed to call a meeting of the Pan-American nations to develop the dream of a transcontinental railway. He predicted that the engineer would be increasingly influential in bringing about Pan-American solidarity and in the attainment of international peace.

Elmer A. Sperry, of New York, reporting upon his mission to Japan, told of the remarkable progress being made by the Japanese in industry and in engineering, saying that even England had come to Tokio to gain new ideas in warship construction. Mr. Sperry described the huge size of the industrial plants and machinery used in Japan as exceeding anything known in the United States. The Japanese people, he said, were keeping the disarmament compact to the letter, while the engineers of Japan were aiming to promote a better international understanding by effecting closer relations with the engineers of other nations.

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GELASIO CAETANI
Mining Engineer and Newly Appointed Italian Ambassador

## Commonwealth Edison Buys Parsons Turbine

That a 40,000-kw. Parsons turbo-generator has been purchased by the Commonwealth Edison Co. for use in the new Crawford Avenue station in Chicago was announced last week. The set, purchased from C. A. Parsons & Co., Newcastle-on-Tyne, England, will operate at a throttle pressure of 550 lb., with a total steam temperature of 725 deg. F., and after passing through the high-pressure end of the turbine the steam will be reheated to the initial temperature.

This is the second turbo-generator of Parsons manufacture that the Commonwealth Edison Co. has purchased, the first being a 25,000-kw. set purchased in 1912 and installed in the Fisk Street station. Sargent & Lundy, of Chicago are the engineers in charge of design, with Merz & McLellan, of London, England, acting as advisory engineers. The other turbines will be mainly of American manufacture. The station is designed for an ultimate capacity of 500,000 kilowatts.

## F.A.E.S. Not a Super-Society

**Defend Federation Idea at Meeting of Council—Recommend Engineer as Secretary of Interior**

DURING the course of the American Engineering Council's annual meeting, dissatisfaction with the conduct of the affairs of the Federated Societies was voiced. The point was made that member societies had too little voice in what was being done and some fear was expressed that an effort might be made to make of the Federation a "super-society." In answer it was pointed out by President Cooley and by L. W. Wallace, the executive secretary, that every effort has been made to conduct the Federation so that it would be a sort of House of Representatives—highly responsive to, and in no way dominating, its constituencies. Certain other functions of the Federated Societies were likened to that of an embassy in Washington, representing member organizations. It was established that ample opportunity has been afforded the membership of the member societies to acquaint themselves with all details of the Federation's activities.

In the end the difficulties were ironed out and the general discussion by members of the Council indicated a complete sympathy with the broad purposes of the Federation, but emphasized the need of devising every means possible to acquaint the individual engineer, as well as the member societies, with the work completed and problems to be undertaken by the Federation and its committees.

A proposal to recommend to President Harding the selection of "the engineering type of man" as Secretary of the Interior to succeed Mr. Fall was referred to the Committee on Public Affairs.

The officers for the coming year were announced in last week's issue. The new executive board is made up as follows:

A.S.M.E.—L. P. Alford, Fred J. Miller, New York; Dean A. M. Greene, Jr., Princeton University; John L. Harrington, Kansas City, Mo.; Dean Perley F. Walker, University of Kansas.

A.I.E.E.—C. G. Adsit, Atlanta; F. B. Jewett, William McClellan, L. F. Morehouse, New York; Prof. C. F. Scott, Yale University.

A.I.M.E. — Galen H. Clevenger, Boston; Charles H. MacDowell, Chicago; Allen H. Rogers, Boston.

Joint Representation of American Society of Safety Engineers, American Society of Agricultural Engineers, Society of Industrial Engineers and American Institute of Chemical Engineers — Morton G. Lloyd, U. S. Bureau of Standards, Washington; S. H. McCrory, U. S. Bureau of Public Roads, Washington; Prof. Joseph W. Roe, New York University.

S. H. McCrory was elected chairman of the Finance Committee. The following regional directors were chosen:

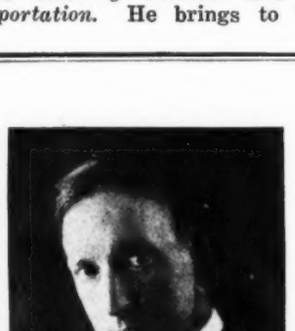
District No. 1, A. E. Lindau, Buffalo, N. Y.; District No. 2, W. H. Hoyt, Duluth;

District No. 3, Charles R. Gow, Boston; District No. 4, W. J. Fisher, York, Pa.; District No. 5, Erskine Ramsay, Birmingham, Ala.; District No. 6, L. A. Canfield, Des Moines, Iowa; District No. 7, O. H. Koch, Dallas, Tex; District No. 8, J. C. Ralston, Spokane, Wash.

It was voted to hold the next meeting of the executive board in Cincinnati, Ohio, during the last half of March, the exact date to be fixed later.

### Street Joins McGraw-Hill Co. as Vice-President

Well known for the last ten years as general manager of distribution of the Western Electric Co., O. D. Street has joined the McGraw-Hill Co., Inc., in the capacity of vice-president in charge of the *Electrical World, Electrical Merchandising, Journal of Electricity and Western Industry, Industrial Engineer, Electric Railway Journal* and *Bus Transportation.* He brings to these



O. D. STREET

publications a broad background of business training and an extensive contact in the electrical industry.

Mr. Street entered the organization of the Western Electric Co. in 1901 on his graduation from Williams College. He was in charge of telephone sales on the Pacific Coast, assistant to the president, Atlanta branch manager, general telephone sales manager and latterly general manager of distribution. During the war he rendered invaluable service in reorganizing the warehousing division of the Quartermaster's Corps and establishing an orderly system of forwarding to Pershing's army where chaos had existed before. He has become a recognized authority on the broad problem of distribution, now one of the most pressing issues before the industries of America.

## Personal Mention

**L. J. Gibbons,** previously with Maher Engineering Co., is now associated with the Chicago office of the Standard Turbine Corporation.

**F. C. Shenehon** has been appointed vice-president and general manager of construction and engineering of the Byllesby Engineering and Management Corp., Chicago, Ill. As consulting engineer of the firm of Shenehon & Meyer, Minneapolis, Minn., Mr. Shenehon has performed important services for the United States Government, the Niagara Hydraulic Power Co. and the Chicago Drainage Canal. For eight years he was dean of the College of Engineering and Architecture, University of Minnesota, from which he was graduated in 1885. **F. H. Lane,** manager of engineering and construction, will remain in his present position as Mr. Shenehon's ranking assistant.

## Society Affairs

**Toronto Section, A.I.E.E.,** will hear P. E. Hart on "Large Power Distribution and Control" at its meeting on Jan. 26.

**At Carnegie Institute of Technology,** Pittsburgh, Pa., on Jan. 24 at 8:30 p.m., W. S. Murray will give a lecture on "The Superpower System."

**Chicago Section, A.S.M.E.,** will meet Jan. 29 at the Sherman Hotel. John L. Harrington, national president of the society, and C. F. Peez, president of the Link Belt Co., will speak.

**Cleveland Section, A.S.M.E.,** will hold a joint meeting with the A.I.M.E. on Jan. 30. The subject will be "Blast-Furnace Design, Operation and Metallurgy."

## Business Notes

**The Andrews-Bradshaw Co.,** eastern sales representative of the Tracy Steam Purifier, has arranged for representation in the Philadelphia territory by the Sheffler-Gross Co., Drexel Bldg., Philadelphia, Pa.

**The Chain Belt Co.,** Milwaukee, has appointed F. S. Bosworth as manager of the Chicago office. Mr. Bosworth has been in charge of the company's St. Louis office for the last three years. With him will be associated Raymond X. Raymond, for several years connected with the export sales department in Milwaukee. Thomas F. Scannell, formerly of the Chicago office, has been placed in charge of the St. Louis office.

**The Tokyo Electric Light and Power Co.,** supplying the City of Tokyo, Japan with electrical energy, has recently placed with the Westinghouse Electric & Manufacturing Co. a large order for generating and switching equipment to be used in extensions now being made to its system. The order covers switchboard, switching and generating equipment to be used in four of the company's stations—the Nakatsugawa No. 1 step-up transformer station, the Kumagaya switching station, the Komatsu step-up transformer station and the Kamekuya generating station. The generating apparatus to be installed in the Kamekuya station consists of three 6,660-kva. 90-per cent power factor three-phase 50-cycle 500-r.p.m. vertical waterwheel generators.

## Coming Conventions

**Iowa Engineering Society;** Lloyd A. Canfield, secretary, 406 Flynn Bldg., Des Moines. Annual meeting at Des Moines, Jan. 23-26.

**American Society of Heating and Ventilating Engineers,** 29 West 39th St., New York City. Annual meeting: Jan. 23 at New York City, Jan. 24-26 at Washington, D. C.

**American Boiler Manufacturers' Association;** H. N. Covell, 191 Dikeman St., Brooklyn, N. Y. Winter meeting at New York City, Feb. 12.

**American Institute of Electrical Engineers,** 29 West 39th St., New York City. Mid-winter convention at New York City, Feb. 14-16.

**Universal Exposition of Inventions and Patents,** Grand Central Palace, New York City, Feb. 17-22.

**American Institute of Mining and Metallurgical Engineers,** 29 West 39th St., New York City. Annual meeting at New York City, Feb. 19-21.

**American Association of Engineers,** 63 East Adams St., Chicago, Ill. Annual convention at Norfolk, Va., May 7-9.

**National Electric Light Association;** M. H. Aylesworth, 29 West 39th St., New York City. Annual meeting at New York City, June 4-8.

## Fuel Prices

### BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine run bases, f.o.b. mines):

| Coal | Market Quoting | Jan. 8 1923 | Jan. 15, 1923 |
|---|---|---|---|
| Pool 1, | New York | 6.00–6.75 | $5.50–6.00 |
| Smokeless, | Columbus | 6.50–6.75 | 6.50–6.75 |
| Clearfield, | Boston | 4.75–5.50 | 4.50–5.25 |
| Somerset, | Boston | 5.00–5.75 | 4.75–5.50 |
| Kanawha, | Columbus | 3.50–4.00 | 3.50–4.00 |
| Hocking, | Columbus | 3.00–3.25 | 3.00–3.25 |
| Pittsburgh No. 8 | Cleveland | 3.40–3.65 | 3.35–3.50 |
| Franklin, Ill., | Chicago | 4.00–4.25 | 3.75–4.00 |
| Central, Ill., | Chicago | 3.25–3.75 | 3.25–3.75 |
| Ind. 4th Vein, | Chicago | 3.75–4.00 | 3.50–3.75 |
| West Ky., | Louisville | 2.50–3.00 | 3.35–3.75 |
| S. & E. Ky, | Louisville | 3.50–4.00 | 3.00–4.00 |
| Big Seam, | Birmingham | 2.50 | 2.25–2.50 |

### FUEL OIL

**New York**—Jan. 18, Port Arthur light oil, 22@25 deg. Baumé, 4⅞c. per gal.; 30@35 deg., 5½c. per gal., f.o.b. Bayonne, N. J.

**Chicago**—Jan. 13, for 24@26 deg. Baumé, $1 per bbl.; 32@36 deg., 3c. per gal. in tank car.

**Philadelphia**—Jan. 15, 26@28 deg. Baumé, Oklahoma, 90@95c. per bbl.; 30@34 deg., Oklahoma (group 3), 2⅝@2¾c. per gal.; 16@20 deg. Seaboard, $1.30@$1.40 per bbl.

**St. Louis**—Jan. 15, Oklahoma, 24@26 deg., 95c. per bbl.; 26@28 deg., $1 per bbl.; 28@30 deg., $1.05 per bbl.; Gas oil 32@36 deg., 3c. per gal.; 36@40 deg., distillate, 3½c. per gal.

**Pittsburgh**—Jan. 9, f.o.b., refinery, Penn., 36@40 deg., 5½@5¾c. per gal.; Kentucky, 26@30 deg., 4c.; Gas oil, 32@36 deg., 2¼@2⅜c.; 36@38 deg., 2½@3c.; 38@40 deg., 90c.@$1.05 per bbl.

**Dallas**—Jan. 13, 26@30 deg., $1.30 per bbl.

# New Plant Construction

**PROPOSED WORK**

**Ala., Sheffield**—The U. S. Engineers Office, War Dept., Wash., D. C., will receive bids until Feb. 12, for furnishing and delivering an electric generator 937.5 kva. capacity with exciter.

**Ork., Newport** — The Dixie Power Co., W. Powell, Purch. Agt., is in the market for electric generators, cables, poles, cross bars and insulators.

**Ariz., Phoenix**—The Salt River Valley Water Users' Assn., plans the construction of Mormon Flat dam 166 ft. high 90 ft. wide and 27 ft. thick at bottom, 8 ft. thick at top, the canyon 320 ft. across top dam, capacity 90,000 acre ft. Taintor gates will be used, also additions to Roosevelt dam consisting of 19 Taintor gates in spillway, each gate 20 ft. wide and 15 ft. high, thus adding 15 ft. to the available height of dam, the installation of a turbine and generator which will make it possible to generate 16,000 kw., an additional 270,000 acre ft. of water will be impounded, depth to bed rock about 50 ft. Bids will be received until Feb. 5 for 10,000 hp. turbine to operate under 160 ft. effective head at 300 r.p.m., 7.500 kva. generator, 25 cycle, delivering 2,300 volts for power house at Roosevelt dam, estimated cost $130,000 to $140,000. A bond issue of $1,800.000 was authorized by vote Jan. 4 for above projects. C. C. Craign Ch. Engr. and F. J. O'Haara, Ass't. Ch. Engr.

**Calif., Fresno**—R. F. Felchlin Co., Bank of Italy Bldg., is receiving bids for the construction of a 10 story office building on J and Toulumne Sts., for the San Joaquin Light & Power Co., 1801 Tulare St. Estimated cost $600,000. Equipment detail not reported. Noted June 20, 1922.

**Calif., Glendale** — The Glendale Union High School Dist., will receive bids until Jan. 25, for the construction of school buildings, consisting of a 2 story administration, auditorium and classroom building, and a 2 story science building. Estimated cost $500,000. J. C. Austin, Baker-Detwiller Bldg., Los Angeles, Archt. Equipment detail not reported. Noted May 23, 1922.

**Calif., Manteca**—C. R. Lenfest, 1195 East Santa Clara St., San Jose, has been granted permit by the State Water Comn., for the construction of 11,750 ft. of canals, 25.8 ft. wide on top, 12 ft. on bottom, 3.4 ft. through earth, also installation of 2 pumping plants, operated by electric motors of 100 hp. cap. Estimated cost $30,000.

**Calif., Santa Rosa**—The National Ice & Cold Storage Co., Postal Telegraph Bldg., San Francisco, is having plans prepared for addition to cold storage plant. Estimated cost $100,000. Private plans. Equipment detail not reported.

**Idaho, Weippe** — The Lolo Lumber Co. plans the construction of a complete sawmill, dam, power engine, also boiler house, machinery, etc. Estimated cost $35,000. Quotations wanted on sawmill equipment.

**Ill., Chicago**—The Lockwood & Strickland Co., 723 West 49th Pl., is in the market for 75 to 100 hp. d.c. generator, two 25 hp. motors, 220 volt, 200 A.H. storage battery, and switchboard, for machine shop.

**Ill., McLeansboro**—W. A. Fuller, 1917 Railway Exchange Bldg., St. Louis, Mo., is preparing plans for waterworks system to consist of large impounding reservoir, rapid sand filter plant, new dam, several miles of pipe lines, new engines and generators. Connection with electric power plant.

**Ill., Waukegan**—T. Goldsmith, 219 Belvidere St., is in the market for refrigeration machinery.

**Ind., Cannelton**—The Cannelton Sewer Pipe Co., is in the market for a 350 hp. Corliss engine best type, 2 wet pans, 10 ft. drying pan, electric vibrating screen. 44 x 60 in. press, 2 gravity elevators, steam hydraulic elevator and a 179 ft. conveyor running at a 12 degree angle. Contract for the construction of a 4 story, 75 x 130-ft. sewer pipe factory. including 32 kilns, 120 ft. radial stack, also power plant, etc., has been awarded to the Hoffman Constr. Co., Furniture Bldg., Evansville. Estimated cost $200,000. Noted Dec. 26, 1922.

**Ind., South Bend**—The Epworth Hospital is having revised plans prepared for the construction of a 5 story hospital, including refrigerating plant, on West Navare St. Estimated cost $350,000. R. E. Schmidt, 104 South Michigan Ave., Chicago, Ill., Archt.

**Kan., Norton**—The city, E. L. Guthrie, Clk., is in the market for one Diesel, semi-Diesel or steam, 300 hp. engine with boilers and complete with steam equipment, direct connected to a 245 kva. 3 phase, 60 cycle, 2300 volt generator, together with belted exciter.

**La., Bunkie**—The town board will receive bids until Jan. 30. for the construction of an auxiliary pumping unit, 4 mi. water lines., c.i. pipe, hydrants and valves. Estimated cost $50,000. Kramer Engr. Co., Magnolia, Miss., Engrs.

**La., New Orleans**—E. Weil, Archt., Whitney Annex, will receive bids until Feb. 1, for 5 story, 50 x 296 ft. clinic, maternity and ward building, including heating, electrical work, refrigeration, etc., for the Touro Infirmary, Prytania and Louisiana Ave. Estimated cost $750,000.

**Md., Back River** (Baltimore P. O.)—M. J. Ruark, Sewerage Engr., City Hall, is preparing plans for the construction of an auxiliary sludge pumping station, a plant building and a waiting station.

**Md., Baltimore**—The American Ice Co., Calvert Bldg., will soon award the contract for the construction of a 2 story, 80 x 143 ft. ice manufacturing plant on Eden St. Estimated cost $100,000. C. L. Weir, 41 East 42nd St., New York, Archt. Ice making machinery will be installed.

**Md., Baltimore**—C. N. and N. Friz, Archts., Lexington Bldg., will receive bids until Jan. 30 for a 6 story, 68 x 110 ft. club building, on Saratoga and St. Paul Sts., for the City Club. Estimated cost $650,000. H. F. Doleman, 507 North Charles St., Engr. Bids for heating, ventilating, wiring, etc., will be received by C. L. Reeder, 916 North Charles St., Mech. Engr.

**Md., Baltimore**—The city council, City Hall, is having plans prepared for the construction of a 3 story, 111 x 211 ft. school, including steam heating and ventilating systems, on Jackson Pl., Fairmount Ave., Ann and Fayette Sts. Estimated cost $700,000. T. W. Pietsch, American Bldg., Archt. H. Massart, 324 North Charles St., Engr. J. Posey, 11 East Pleasant St., Engr., for mechanical equipment.

**Mass., Boston**—The city will soon award the contract for the construction of a high school on Dunbar Ave. Estimated cost $1,000,000. McLaughlin & Burr, 88 Tremont St., Archts. Equipment detail not reported. Noted Nov. 28, 1922.

**Mich., Battle Creek**—The Quartermaster General's Office, 2312 Munitions Bldg., Wash., D. C., will receive bids until Feb. 16 for the construction of a 500-bed neuropsychiatric hospital, to consist of 30 buildings, including complete sewer, water, heating and lighting systems, etc., at Camp Custer, here. Noted Aug. 22. 1922.

**Mich., Detroit**—B. C. Whitney, Detroit Opera House Bldg., is having plans prepared for the construction of an 8 story, 94 x 165 ft. theatre and office building, including steam heating system and electrical equipment, on East High St. Estimated cost about $2,000,000. Rapp & Rapp, 190 North State St., Chicago, Ill., Archts.

**Mich., Detroit**—The Women's City Club, 141 Bagley Ave., is having plans prepared for the construction of a 6 and 9 story, 90 x 120 ft. club house, including heating and ventilating, boilers and equipment, on Park Ave. and Elizabeth St. Estimated cost $500,000. W. B. Straton, Union Trust Bldg., Archt.

**Mich., Portland**—The Municipal Power Plant, C. L. Jenkins, Supt., is receiving bids for equipment including 200 hp. oil engine, 12,000 gal. steel tank, 2,300 volt, 2 phase, 60 cycle direct connected generator. Estimated cost $12,000. Burd & Giffels, 422 Kelsey Bldg., Grand Rapids, Engrs.

**Minn., St. Paul**—The city, H. W. Austin, Purch. Agt., City Hall, is in the market for one 140 cu.ft. cap., portable gas engine driven air compressor.

**Mo., St. Louis**—The Burke Sales Co., T. F. Burke. Purch Agt., 1623 Chemical Bldg., is in the market for a portable 60 hp. boiler, to stand a test of 125 lb. pressure, also 6 hp. upright engine and a portable forge.

**Mo., University** — The Egyptian Court Ant. Bldg. Co., Clayton, will soon receive bids for the construction of a 6 story, 100 x 159 ft. apartment building, including steam heating and vacuum cleaning system and fan ventilation, on Delmar Blvd., here. Estimated cost $500,000. J. W. Leigh, Railway Exchange Bldg., St. Louis, Archt.

**N. J., Belleville** — The Westinghouse Lamp Co., 60 India St., Boston, Mass., is having plans prepared for the construction of a plant, here, for the manufacture of lamp bases. Estimated cost $750,000. Stone & Webster, Inc., 147 Milk St., Boston, Mass., Archts. Equipment detail not reported.

**N. Y., Dunkirk**—The Bd. Water Comrs., is in the market for electrical pumping machinery to be used in connection with waterworks extensions.

**N. Y., Gouverneur**—The W. H. Loomis Talc. Co., is in the market for electric motors for talc mill.

**N. Y., Jamestown**—The Bd. Educ., will receive bids until Feb. 6, (change of date), for the construction of 2 Junior High schools on Front and Buffalo Sts. Estimated cost $750,000. Betelle & Gilbert, 546 Broad St., Newark, N. J., Archts. Equipment detail not reported. Noted Nov. 7, 1922.

**N. Y., Lackawanna**—The Niagara, Lockport & Ontario Power Co., F. D. Corey, Pres., 700 Lafayette Bldg., Buffalo, purchased 12 acre site and plans the construction of a new power plant and transmission lines here. Estimated cost $200,000.

**N. Y., New York**—The Manhattan Brass Co., E. F. Gennert, Mgr., 332 East 28th St., plans improvements to power plant, including installation of 300 hp. boilers and engine. Estimated cost $20,000. Dr. A. A. Adler, 9 Murray St., Consult. Engr.

**N. Y., New York**—The Transit Comn., G. McAneny, Chn., 49 Lafayette St., received bids for the construction of transformer closets for emergency lighting on Broadway-Fourth Avenue Rapid Transit Railroad, Boro of Manhattan, from B. T. & J. J. Mack, 200 Bway., $13,428; Benedetto & Sanssez, $13,944; C. J. Adams & Son, Inc., 308 West 20th St., $14,313. Noted Jan. 9.

**N. Y., Niagara Falls**—The Bd. Educ., Gluck Bldg., will receive bids until Feb. 1, for the construction of a high school, to replace one destroyed by fire. Estimated cost $650,000. Associated Architects, Kirkpatrick and Gannon Sts., Archts. Owner is in the market for vocational and mechanical equipment.

**N. Y., Watertown**—The Northern New York Utilities Inc., plans the development of the South Edwards power site, consisting of the construction of a dam, power house, penstock and installation of hydro electric equipment. Estimated cost $500,000. W. P. Creager, Ch. Engr.

**N. Y., Youngstown**—K. Schantz, 78 Main St., Buffalo, is in the market for ice making and cold storage equipment, for plant here.

**N. C., Tuxedo**—The Manufacturers Power Co., Asheville, plans the construction of a hydro electric plant here, the first unit of a hydro-electric development to have an ultimate capacity of 70,000 hp. Estimated cost of first unit $750,000, total cost $3,000,000 to $4,000,000. Mees & Mees, Kinney Bldg., Charlotte, Engrs.

**Ohio, Cincinnati**—The Krug Company, 2718 Woodburn Ave., is in the market for a 200 a.c. 60 cycle electric motor.

**Ohio, Martins Ferry**—The city council plans the construction of a municipal electric light plant and waterworks to include an electric generating station, boiler plant, pumping station, 2 pumps 4,000,000 gal. capacity, ash handling facilities, etc. Estimated cost $450,000. J. N. Chester Engr. Co., Union Bldg., Pittsburgh, Pa., Engrs. Noted Sept. 5.

**Okla., Ardmore**—The Consumers Power Co. is having plans prepared for the construction of a 2 story power plant complete with necessary machinery. Estimated cost $100,000. W. A. Beahr, Peoples Gas Bldg., Chicago, Ill., Engr. Owner will award private contracts for building and machinery.

**Okla., Hurrah**—The Oklahoma Gas & Elec. Co., Insurance Bldg., Oklahoma City, plans the construction of a 22,500 hp. power plant, complete with steam turbine, generating units, and 150 mi. high tension transmission lines to connect with present system. Estimated cost $3,000,000. Byllesby Engineering & Management Corp., 208 South La Salle St., Chicago, Ill., Engrs.

**Okla., Morris**—The city will soon award the contract for the construction of a dirt dam with rapid sand mechanical filter plant, basins, and 10,000 ft. 8 in. c.i. pipe lines and the installation of pumping machinery, including two 150 g.p.m. centrifugal pumps driven by 25 hp. oil engines. Estimated cost $67,000. H. G. Olmsted & Co., Oklahoma City, Engrs. Noted Jan. 9.

**Okla., Tulsa**—The Oklahoma Power Co., plans the construction of new unit to its generating plant 10,000 kw. capacity at West Tulsa.

**Okla., Weatherford**—The city plans election Jan. 23, to vote for the construction of a 1 story, 80 x 120 ft. power plant, including 500 hp. oil engine generators, on Bradley St., also a 20 ton raw water ice plant in connection with power plant. Estimated cost $114,000. V. V. Long & Co., 1300 Colcord Bldg., Oklahoma City, Engrs. Noted Jan. 2.

**Ore., Portland**—The Co-operative Office Bldg. Corp., M. B. McClure, Pres. and Mgr., 664 East 52nd St., N., had plans prepared for the construction of a 12 story, 100 x 100 ft. office building, including steam heating system, on Bway and Yarnhill Ave. Estimated cost $900,000. W. Bruce, Archt.

**Pa., Allentown**—The Allentown Hospital Assn., is in the market for ice and refrigeration machinery and equipment.

**Pa., Eddystone**—The Baldwin Locomotive Works, 500 North Broad St., Phila., plans the construction of 1 and 2 story, factory buildings, engine, foundry, machine shops etc. here. Estimated cost $3,000,000. Private plans.

**Pa., Erie**—The Bury Compressor Co. is in the market for circulating pump, capacity 500 gal. per min.

**Pa., Harrisburg** — The International Brotherhood Compensation & Relief Fund Inc., has had plans prepared and will receive bids the latter part of February for the construction of a 13 story, 124 x 127 ft. building, consisting of bank and office rooms, lodge room and convention hall including power and ice plants, ventilating system etc., on 6th and Maclay Sts. Estimated cost $1,000,000. C. H. Kain, 317 Chestnut St., Archt.

**Pa., New Kensington**—The New Kensington Ice Co., is receiving bids for the construction of a 1 story 40 x 70 ft. ice plant on 2nd and 7th Sts. Estimated cost $50,000. Private plans. Equipment detail not reported.

**Pa., Phila.**—The Bd. Educ., 19th and Chestnut Sts., plans the construction of a 4 story, 350 x 380 ft. high school on 54th and Berks Sts. Estimated cost $750,000. Private plans.

**Pa., Phila.**—The Philadelphia Hotel Co., A. D. Brennan, c/o R. E. White, Archt., Pennsylvania Bldg., will soon receive bids for the construction of a 20 story, 84 x 219 ft. hotel on Broad and Locust Sts. Estimated cost $3,000,000. Equipment detail not reported.

**S. C., Clover**—The Bd. Pub. Wks., R. L. Wylie, Chn., will receive bids until Jan. 29, for furnishing material, labor, tools and equipment for a complete sewerage system and disposal plants, and for the construction of a ground water reservoir and necessary extensions to the waterworks system, enclosing necessary pumps, c.i. pipe lines, hydrants, valves and all appurtenances. Carolina Engr. Co., Wilmington, N. C., Engrs.

**S. C., Denmark**—The Edisto Public Service Co., is in the market for ice making machinery.

**Tenn., Knoxville**—The Duncan Machinery Co., Dempster Bldg., 721 North Central Ave., is in the market for two 150 hp. horizontal return tubular boilers good for 125 to 150 lb. steam pressure, standard with full flush front, also prices with steel castings and Dutch ovens, 35 to 50 hp. throttling either side of center crank engine, 125 to 250 hp. Corliss engine (used).

**Tenn., Memphis**—The Security Building Co. c/o B. A. Bogy, 46 North 2nd St., had plans prepared and will receive bids the latter part of January, for the construction of a 12 story, 75 x 85 ft. office building, on Front and Madison Sts. Estimated cost $1,000,000. McKim, Mead & White, 101 Park Ave., New York and L. G. Carlisle, Falls Bldg., Memphis, Archts. Equipment detail not reported.

**Tenn., Nashville** — Davidson County Purch. Com., Court House, will receive bids until Jan. 24 for a 20 hp. traction engine with lugs, tools, injector, cub, etc.

**Tenn., Nashville**—The Nashville Abattoir & Hide Assn., 1416 Adams Ave., plans addition to ice manufacturing plant. Estimated cost $6,000.

**Tenn., Nashville**—The Peabody Teachers College plans the construction of a dormitory, estimated cost $200,000, also 4 other buildings, later, consisting of demonstation school, $400,000, administration building, $200,000, men's dormitory, $200,000 and science hall $200,000. Architect not selected.

**Tex., Dallas**—The Buckners Orphan Home, H. F. Buckner, Mgr., is having plans prepared and will receive bids about Feb. 15, for the construction of 2 and 3 story dormitories in 6 units, to replace buildings destroyed by fire Jan. 3. Estimated cost $500,000. Architect not selected. Equipment detail not reported.

**Tex., Dallas**—The Rigsbee Electric Co., 1809 Main St., is in the market for a 25 hp. electric motor.

**Tex., Ft. Worth**—The Ft. Worth Baptist Hospital, Pennsylvania Ave., is having plans prepared for the construction of a 2 story addition to hospital. Estimated cost $250,000. Clarkson & Gaines, 1st Natl. Bk. Bldg., Archts. Equipment detail not reported.

**Tex., Snyder** — J. R. Joyce is in the market for 100 hp. right hand automatic engine, direct connected to shaft, flange coupling or direct clutch coupling, for machine shop.

**Wash., Cheney** — The city will receive bids until Feb. 15th, for a 14 in. well 800 ft. deep, pump, housing, etc., for addition to municipal water supply system. Estimated cost $12,000. Engineer not selected. Noted Dec. 12.

**Wash., Riverside**—The Riverside Irrigation Dist., plans the construction of a power plant, pumps, canals, pipe lines, flumes, etc., bonds have been approved for same. Estimated cost $450,000. Engineer not selected.

**W. Va., Williamson** — The Williamson Ice & Cold Storage Co. is in the market for machinery and equipment for a 5 story ice and cold storage plant.

**Wis., Fond du Lac** — The city, J. J. Breister, Supt. Water Dept., will soon receive bids for furnishing and installing one 5,000,000 to 10,000,000 gal. per day pump, steam or motor driven.

**Wis., Ft. Atkinson** — The Ft. Atkinson Canning Co. plans the construction of a 3 story, 48 x 108 ft. canning factory, also 54 x 54 ft. process building, boiler house, viner building and warehouse, 125 ft. steel stack, etc., and the installation of two 150 hp. boilers. Estimated cost $100,000. McMeans & Tripp, Majestic Bldg., Indianapolis, Ind., Engrs.

**Wis., Madison** — The J. Heilprin Fruit Co., J. Heilprin, Pres., is in the market for refrigerating machinery for proposed fruit storage warehouse. Noted Dec. 7, 1922.

**Wis., Neenah**—The Water Comn., H. S. Zemlock, Secy., plans to drill an additional artesian well and install steam or gas engine driven air compressors. Estimated cost $5,000. Private plans.

**Wis., Racine** — The Progressive Dairy Co., c/o E. F. Buelow, 309 Badger Bldg., is in the market for icemaking and dairy machinery.

**Wis., Sturgeon Bay**—The Fruit Growers Canning Co. plans the construction of a 3 story, 122 x 130 ft. warehouse, 2 story, 84 x 144 ft. preserving building, 1 story, 48 x 98 ft. receiving building and a 125 ft. stack, also the installation of conveying equipment and two 15 hp. boilers. Estimated cost $225,000. McMeans & Tripp, Majestic Bldg., Indianapolis, Ind., Engrs.

**Ont., Campbellville**—The council, R. C. Menzies, Clk., passed by law Jan. 19, authorizing $35,000 bonds for new electric light and power system. Noted Jan. 2.

**Ont., Lansing**—The Twp. of North York, H. D. Goode, Clk., Sterling Bank Bldg., is in the market for 2 electrically driven pumps, 1 gasoline driven pump, pipe, valves, fliters, also elevated steel tank. Noted Jan. 16.

**Ont., Mitchell**—The Whyte Packing Co., 66 Front St., East Toronto, plans the construction of an artificial ice plant, for handling dairy and animal produce, here.

**Ont., Wheatley** — The Village, M. H. Chamberlain, Clk., passed by law authorizing $35,000 for new electric light and power system, work to proceed in the spring. Noted Dec. 12.

## CONTRACTS AWARDED

**Calif., Los Angeles**—A. C. Blumenthal, F. Kahn, et al., Loew State Bldg., awarded the contract for two 12 story office buildings, with connecting arcade, on Mercantile Pl., to MacDonald & Kahn, Loew State Bldg., about $1,500,00. Macdonald & Couchot, 234 Pine St., San Francisco, Archts. Equipment detail not reported. Noted Dec. 26.

**Ill., Chicago**—The Ford Motor Co., Highland Park, Mich., awarded the contract for the construction of a 1 story, 502 x 1,363 ft. assembly plant and 100 x 100 ft. power house to the Avery Brundage Co., 110 South Dearborn St. Arrangements for machinery, electrical equipment, etc., made by owners. Noted Dec. 12, 1922.

**Ind., Indianapolis** — The Meyer-Kiser Bank, 136 East Washington St., awarded the contract for the construction of an 11 story, 60 x 200 ft. bank and office building, to the Bedford Stone & Constr. Co., Fletcher Trust Bldg. Estimated cost $1,000,000. Equipment detail not reported. Noted Oct. 31, 1922.

**La., Houma**—The city council awarded the contract for power house and filtration plant structures and pipe laying to the Merkel Constr. Co., 1733 Walnut St., Kansas City, Mo., $110,000; two 300 hp. crude oil engines with electrical equipment to McIntosh-Seymour Corp., Auburn, N. Y., $55,200. Noted Nov. 21, 1922.

**Md., Baltimore** — The Edgevale Apartments, c/o E. L. Palmer, Jr., Archt., 513 North Charles St., awarded the contract for the construction of a 5 story, 180 x 320 ft. apartment house, on 40th St. and Beech Ave., to L. L. Chambers, 36th St. and Roland Ave., $750,000. Steam heating and ventilating systems will be installed.

**Mo., St. Louis**—The Bd. of Pub. Service, 208 City Hall, awarded the contract for the construction of a 2 story, 54 x 225 ft. service building in connection with the Training School for Feeble Minded, at Scott Farm, to James A. Godfrey & Co., Wainwright Bldg., $107,433; heating to the American Power Piping Co., Merchants-Laclede Bldg., $13,425. Icemaking and refrigeration machinery, gasoline engines and other equipment will be purchased later. Noted Dec. 12.

**Mo., St. Louis**—The Missouri State Life Ins. Co., 1501 Locust Blvd., awarded the contract for the construction of a 5 and 10 story, 100 x 115 ft. addition to office building, to the McKelvey Constr. Co., 811 Title Guaranty Bldg. Estimated cost $750,000. Equipment detail not reported.

**N. H., Sunapee** — The Lake Sunapee Power Co., I. M. Frost, Pres., Rutland, Vt., will build a hydro-electric power plant with dam and a 1500 ft. steel penstock in the harbor, here. Estimated cost $300,000. Private plans. Contracts for generators awarded to the Electric Machinery Mfg. Co., 14th Ave. and N. E. Tyler St., Minneapolis, water wheels to Worthington Pump & Mach. Corp., 200 Devonshire St., Boston, Mass. Noted Oct. 10, 1922.

**N. Y., New York**—The Bricken Constr. & Import Co., c/o Gronenberg & Leuchtag, Archts., 450 4th Ave., will build by day labor, an apartment building at 343 West 86th St. Estimated cost $500,000. Equipment detail not reported.

**N. Y., New York**—The Cortlandt Realty & Constr. Co., c/o Springsteen & Goldhammer, Archts. and Engrs., 32 Union Sq., will build by day labor a 5 story, 251 x 369 ft. apartment building on Grand Concourse. Estimated cost $600,000. Equipment detail not reported.

**N. Y., New York**—Lousons Constr. Co., c/o Gronenberg & Leuchtag, Archts., 450 4th Ave., will build an apartment building on Grand Concourse, by separate contracts, under supervision of Architect. Estimated cost $1,000,000. Equipment detail not reported.

**N. Y., Tupper Lake** — The Bureau of Yards & Docks, Navy Dept., Wash., D. C., awarded the contract for the construction of a U. S. Veterans' Hospital here to the W. H. Sutherland Constr. Co., 408 Compton Bldg., St. Louis, Mo., $1,139,269., Spec. 4718. Noted Dec. 12, 1922.

**Ohio, Delaware**—The Dept. Pub. Service, W. H. Duffy, Dir., City Hall, awarded the contract for the construction of 60 x 80 ft. power house, 30 x 90 ft. laundry, 15,000 gal. coagulating reservoir and 26,000 gal. reserve reservoir at the Girls Industrial Home, Concord, to the Middle States Constr. Co., 524 East Hudson St., Columbus, $97,472. Noted Dec. 19.

**W. Va., Huntington**—The U. S. Engineers Office, awarded the contract for the construction of a power house at Dam No. 30 on the Ohio River, to H. Campbell & Sons, $32,000. Noted Dec. 5.

**Wis., Kenosha**—Kenosha County awarded contract for the construction of 2 and 3 story, 67 x 138 ft. and 126 x 226 ft. court house, administration and jail buildings, to the Hutter Constr. Co., 128 Western Ave., Fond du lac, $695,400; heating to the Thomas Heating Co., 708 9th Ave., Racine, $57,077. Noted Sept. 5.

**Wis., Madison**—The Kennedy Dairy Co., 618 University Ave., awarded the contract for a 1 story, 50 x 75 ft. ice plant, to the C. B. Fritz Co., 138 North Frances St. Estimated cost $40,000. Refrigerating machinery will be installed. Noted July 11, 1922.